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THE SILVICULTURE OF INDIAN TREES

BY

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VOLUME II

Leguminosae (Caesalpinieae) to Verbenaceae

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CONTENTS OF VOLUME II

LIST OF ILLUSTRATIONS, VOLUME II

ORDER XXIII. LEGUMINOSAE (*continued*)

Sub-Order II. CAESALPINIEAE

Genera 1. Caesalpinia, Linn.; 2. Poinciana, Linn.; 3. Acrocarpus, W. and A.; 4. Hardwickia, Roxb.; 5. Saraca, Linn.; 6. Amherstia, Wall.; 7. Tamarindus, Linn.; 8. Cassia, Linn.; 9. Bauhinia, Linn.

1. CAESALPINIA, Linn.

Species 1. *C. Sappan*, Linn.; 2. *C. digyna*, Rottl.; 3. *C. Coriaria*, Willd.

1. **Caesalpinia Sappan,** Linn. Sappan wood.

A small tree or shrub, the wood of which yields a red dye. It is believed to be wild in the Shan hills, and is cultivated in India and Burma.

2. **Caesalpinia digyna,** Rottl. Vern. *Sunletthè*, Burm.

A thorny scandent shrub whose pods, commercially known as tari pods, are very rich in tannin. It is found wild in many parts of Burma and Assam as well as in Bengal, occurring on waste lands and in hedgerows, chiefly near villages; it prefers well-drained ground with sandy soil and avoids badly-drained localities. The seeds are very hard and germination is difficult. Mr. I. H. Burkill[1] found that prolonged soaking had no effect, but by cutting through the outer impervious layer of the seed-coat with a minute cut germination was readily induced: Mr. W. A. Robertson informs me that in Burma germination is induced by filing through the testa. At Dehra Dun it was found that germination took place almost at once, without any harm to the seed, by soaking the seed in hot water and then removing the softened testa.

3. **Caesalpinia Coriaria,** Willd. Divi-divi, American sumach.

A small tree of the West Indies, cultivated, chiefly in southern India, for the sake of its pods, which give a valuable tanning material. It grows well in Lower Burma, bearing pods in quantity; some years ago there was a small experimental plantation at Tharrawaddy, in which the trees bore pods in abundance. It prefers well-drained ground, becoming stunted on stiff soil; in the Tharrawaddy plantation there was a marked difference where the soil became clayey.

2. POINCIANA, Linn.

Species 1. *P. regia*, Bojer; 2. *P. elata*, Linn.

1. **Poinciana regia,** Bojer. Gold mohur.

A native of Madagascar; largely grown for ornament in the warmer and moister parts of India and Burma. It is almost evergreen, and has a broad spreading crown of feathery foliage, large flaming red flowers which appear chiefly in April and May, and broad flat pods 1 to 2 ft. long, which ripen in the rainy season and remain long on the tree. It is usually grown from seed, but can also be raised from cuttings. It is fast growing, and has spreading superficial roots which kill out other plants. Its shallow root-system renders it liable to be blown down during storms.

[1] Gardens Bulletin, Fed. Malay States, vol. i, No. 6, 1913, p. 193.

2. **Poinciana elata,** Linn. White gold mohur.

A small practically evergreen tree with feathery foliage and handsome yellowish white flowers which turn orange as they fade; the flowers appear in the hot season or early rains. Wild, possibly indigenous, in the Bardé hills in Porbunder state, Kathiawar; probably not wild elsewhere in India. The tree is capable of growing on poor dry soil, and in the Bardé hills it grows in the crevices of trap and basalt rocks, where however it is stunted. It is often cultivated for ornament. It grows fast and is easily raised from seed.

3. ACROCARPUS, W. and A.

Acrocarpus fraxinifolius, Wight. Vern. *Mandania*, Nep.; *Handige, havalige*, Kan.; *Malaikonnai*, Tam.; *Balanji*, Coorg; *Yetama, mayahnin*, Burm.

A very large deciduous tree, usually with large buttresses at the base. Leaves bipinnate, with three or four pairs of pinnae each about a foot long: the young leaves are bright red. Bark thin, light grey. Heartwood light red, moderately hard, used for shingles, tea-boxes, furniture, and building. The tree is one of the largest in India. Colonel Beddome mentions that in southern India he has seen trees fully 200 ft. high and 150 ft. to the first branch;[1] he records a tree 27 ft. in girth above buttresses. Mr. Gamble states that Sir D. Brandis in his company measured a tree at Dalingkot in the Sikkim Himalaya 181 ft. high and 110 ft. to the first branch.

Distribution and habitat. The natural habitat of the tree is in the evergreen forests of the Western Ghats, chiefly on hill slopes up to 4,000 ft., Sikkim, ascending to 4,000 ft., Duars, Assam, Chittagong, and Burma. It is a tree of the regions of heavy rainfall, but Mr. Tireman mentions that in Coorg it has been cultivated for shade over coffee as far east as the 70 in. rainfall zone.

Flowering, fruiting, and silvicultural characters. In southern India the flowers appear from November to January, when the tree is leafless. The fruits ripen from April to June. The tree is easily raised from seed, some of which germinates within a week, while some may lie dormant for as long as a year before germinating. Bourdillon notes that it reproduces well and the growth is fast. It is sensitive to frost. It is somewhat light-demanding, though capable of standing some shade in youth.

Germination (Fig. 137, *b–f*). Epigeous. The radicle emerges from one end of the seed; the hypocotyl elongates and carries above ground the cotyledons enclosed in the testa, which soon falls off with the expansion of the cotyledons.

The seedling (Fig. 137).

Roots: primary root moderately long, terete, tapering, wiry, flexuose: lateral roots moderate in number and length, fibrous. *Hypocotyl* distinct from root, 1·1–1·8 in. long, terete or slightly compressed, glabrous or minutely pubescent in the upper part. *Cotyledons* sessile, foliaceous, somewhat fleshy, 0·4–0·7 in. by 0·3–0·4 in., elliptical or oblong, entire, glabrous, apex and base rounded. *Stem* erect, woody, yellow to rusty tomentose, particularly in the younger parts; internodes 0·2–1 in. long. *Leaves* alternate, compound, paripinnate, first 1–3 leaves with 3 pairs of leaflets, the number increasing to

[1] Ind. Forester, ii (1876), p. 196.

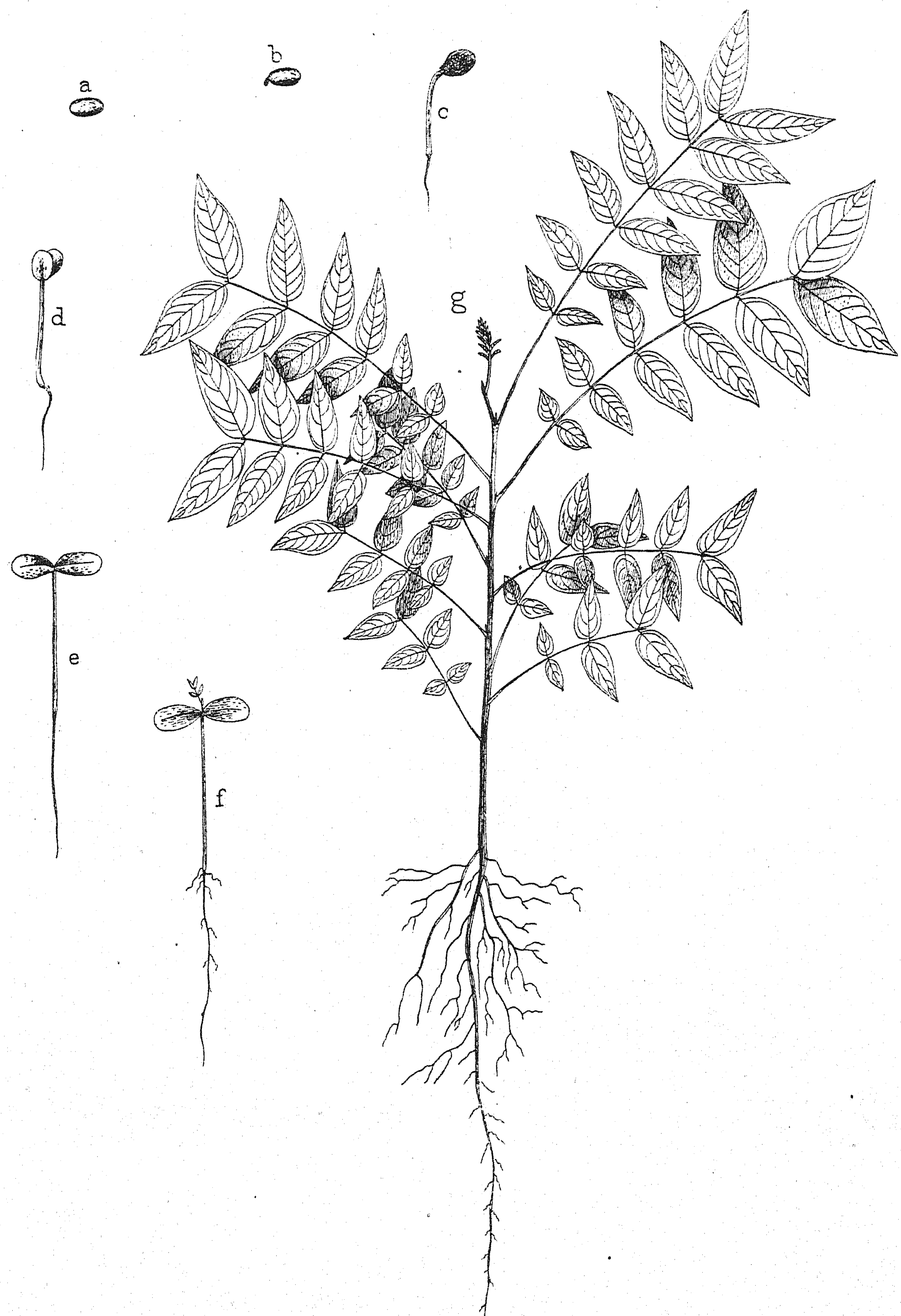

FIG. 137. *Acrocarpus fraxinifolius.* Seedling $\times \frac{1}{2}$.
a, seed ; *b–f*, germination stages ; *g*, seedling six months old.

6 pairs by the end of the first season. Stipules minute, yellow tomentose. Rachis 1 in. (in the earliest leaves) to 5 in. long, yellow or rusty tomentose, terminating in a fine bristle. Leaflets opposite, with petioles up to 0·05 in. long, larger towards apex than at base of leaf, those of earlier leaves 0·2–1 in. by 0·1–0·5 in., those of later leaves 0·4–2 in. by 0·2–0·8 in., ovate, acute or acuminate, base rounded or acute, entire, finely pubescent to glabrescent, lateral veins up to eight pairs.

Rate of growth. Mr. Tireman recorded in 1916 the measurements of thirty-seven young trees in an abandoned coffee estate at Mercara, Coorg. These trees were raised from seedlings about a foot high collected in the forest and planted in 1908, and at the time of measurement were therefore about eight or possibly nine years old from seed. The plants had received practically no attention since they were planted. In 1916 their height varied from 7 to 24 ft. and averaged 15 ft., while their girth varied from 4·5 to 31 in. and averaged 10·9 in.

4. HARDWICKIA, Roxb.

Species 1. *H. binata*, Roxb.; 2. *H. pinnata*, Roxb.

1. **Hardwickia binata,** Roxb. Vern. *Anjan*, Hind., Mar. ; *Kamra, karachi*, Kan. ; *Acha*, Tam. ; *Yepi, naryepi, yapa*, Tel.

A moderate-sized to large tree, leafless for a short time or nearly evergreen, with graceful drooping slender branchlets and greyish green coriaceous bifoliate leaves, the leaflets 1–2·5 in. by 0·5–1·2 in. ; crown conical in early life, becoming broader afterwards. Bark of saplings almost silvery white and smooth, gradually changing as the tree gets older to dark grey and rough with irregular vertical cracks, 0·5–1 in. thick, exfoliating in narrow flakes. In isolated situations or on poor shallow soils the tree tends to branch low down and produce a short bole, but when grown in a fairly crowded crop on favourable soil it produces a long straight cylindrical bole with an elevated crown.

The dimensions vary greatly according to locality. On trap formations, characterized by a shallow and somewhat stiff soil, the tree rarely attains a height of 60 ft. and often does not reach a height of more than 30–40 ft. with a maximum girth of 3 ft. On deeper sandy soil overlying sandstone, granite, and other formations it may attain a height of 80–100 ft. and a girth of 6–10 ft., with a clean cylindrical bole 40–50 ft. in length. Haines says that in the Kymore hills near the Sone river it reaches a height of 120 ft. Mr. E. D. M. Hooper records a tree with a large gnarled trunk 15 ft. in girth in the Raja's garden at Sandur, Bellary district, Madras. Almost everywhere the trees have been much mutilated by pollarding for the sake of fodder, manure, or bast fibre, and in most localities the larger trees are old pollards. Large trees are very frequently hollow, owing, it is generally held, to former damage by fire and mutilation, and possibly also to the repeated dying back in the seedling stage producing a centre of infection for subsequent decay.

The wood is perhaps the hardest and heaviest in India, the weight averaging 82 lb. per cubic foot. The sapwood is small and white, the heartwood dark reddish brown streaked with purple, close grained, very durable, used for bridge and house construction, agricultural implements, carts, wheelwork, &c. The bast yields a strong fibre largely employed for ropes, and the branches are much lopped for manure and cattle-fodder.

Distribution and habitat. The tree is distributed in isolated blocks and patches varying in extent in the drier parts of the Indian Peninsula, extending as far north as the Banda district, United Provinces. In Madras it occupies well-defined areas in the Godavari, Kistna, Kurnool, Bellary, North Arcot, Anantapur, Cuddapah, Nellore, and Salem districts. In Bombay it is fairly common in parts of Khandesh and Nasik, and is found scattered in the dry scrub forests of eastern Belgaum; Talbot says there is a small isolated patch in the Ranebennur subdivision of the Dharwar district. In the Central Provinces and Berar it occurs in parts of Buldana, Nimar, Hoshangabad, and South Chanda. In Buldana it is found in the Amdari, Geru-Matergaon, and Ghatbori reserves and intervening forests over an area of about 182 square miles. It is fairly plentiful in Nimar, and occupies restricted areas in Hoshangabad and South Chanda (south of Allapalli and in Sironcha), while it has been introduced artificially in Nagpur and elsewhere. In Chota Nagpur it is found only in Palamau, especially towards the Sone, on the other side of which, in the Kymore hills, it is frequent (Haines). It occurs locally in Mysore and in some of the Central India states, for example in Indore and Gwalior. The remarkably local distribution of the species, which is not altogether accounted for by soil and climate, is somewhat puzzling, and has not yet been satisfactorily explained.

The rock and soil on which the tree grows have a marked influence on its growth. In many localities, for example in parts of Nimar and Buldana, in Khandesh and Nasik, the underlying rock is trap and the soil is usually very shallow, soon merging into hard *murram* and thence into solid rock. On this formation it is often remarkably gregarious, forming pure crops of greater or less extent where the trees, which are frequently in the pole or sapling stage, may grow thickly together. On such ground, however, it never attains the large dimensions which it reaches on more porous soils overlying rocks which disintegrate more readily than trap. Thus the best growth is attained on sandstone, conglomerate, quartzite, granite, and schist, with an overlying soil of sandy loam or, what is a very characteristic soil for *Hardwickia*, a quartzose reddish gravelly sand. On such formations the tree frequently attains a large size, even though the overlying soil may not be deep, since the taproot has a wonderful capacity for making its way through fissures in solid rock. Here, however, it is not so characteristically gregarious as it is on trap, for although it may form pure crops it is also commonly found scattered among a miscellaneous growth of other species.

Some examples may be quoted of the occurrence of *Hardwickia binata* on shallow soil overlying trap rock. In East Khandesh, Bombay, the tree is almost pure over considerable areas, particularly on the higher ground with poor shallow soil; in places it is mixed with teak, *Anogeissus latifolia*, *Boswellia serrata*, and *Acacia Catechu*. The trees are of comparatively small size, attaining their maximum girth, about 4 ft., in the Jamner reserve: most of the trees are hollow, owing, it is believed, to former fires. In the adjoining Nasik district it occurs pure towards the Khandesh border, becoming scarcer on proceeding west until it disappears and gives place to scrub: the soil is poor and shallow and the trees are of small size. In the Nimar district of the Central Provinces *Hardwickia binata* occupies a considerable portion of the

trap areas along the branch of the Satpuras forming the watershed between the Nerbudda and the Tapti. Regarding these trap areas Mr. D. O. Witt states :[1] 'On the extreme west we find the Anjan scattered and fairly plentiful, but proceeding east it becomes less so, until we reach the railway at Mandwa, where it practically vanishes, hardly a single tree being found throughout the whole of the ridge east of the railway. Isolated Anjan are found on Samardes, and it is fairly common at the western extremity of the ridge separating Nimar from the Berar plain. It does not grow to any great size in these areas. Proceeding to the areas north of the main central ridge, we find the low and undulating hills of the Khandwa range fairly stocked with Anjan, and to the extreme west of this range, and extending almost up to the Nerbudda, we find a peculiar type of Anjan growth, viz. isolated blocks of practically pure Anjan in the pole stage, growing closely and thickly together. Old mature trees are few and far between, and where found are of small dimensions, and have invariably at some time or other in their life been pollarded. That the present pole growth is the natural regeneration of a previously existing Anjan forest goes without saying, but the manner of its formation is a subject of much speculation. . . . The average height of a mature Anjan tree throughout these areas may be put at 40 ft. and its girth at 3 ft.' Fig. 138 shows a sapling crop on trap in the Nimar district. In the Buldana district of Berar *Hardwickia binata* predominates over the greater part of the trap areas, *Boswellia serrata* being its chief companion. The forest is of poor quality, the trees having been much hacked and pollarded; the maximum height and girth of the existing trees are 25 ft. and 2 ft. respectively on the hill slopes, and 30 ft. and 3 ft. respectively on the better soil of the valleys.

Examples of the other geological formations on which *Hardwickia binata* is typically found, consisting for the most part of sandstone or metamorphic rock, occur in numerous localities. The overlying soil, as already mentioned, consists chiefly of a reddish gravelly sand or sandy loam, and although the tree is often scattered among other species, as a rule it attains much larger dimensions than it does on the stiffer soil of the trap areas. In the Kurnool district of Madras it occurs in greater or less abundance on the quartzites, sandstones, and shales of the Yerramalai hills, chiefly on reddish gravelly sand or on sandy loam, either in gregarious patches of varying extent or mixed with *Soymida febrifuga*, *Terminalia tomentosa*, *Anogeissus latifolia*, *Albizzia amara*, and teak. In some of the forests of the Cumbum range of Kurnool old trees may be found scattered amongst a thick growth of bamboos. Mr. E. M. Crothers[2] states that the only species with which it forms a good mixed crop is *Anogeissus latifolia*.

In the Bellary district it is found on rocky quartz soils, and in the forests of the Harpanahalli range it is probably the most numerously represented species, occurring chiefly on the more level ground at the bases of the several hill ranges; it is most abundant on the southern slopes of the Sogi reserve and at the base of the Hyarada hills, where it forms nearly pure forests.[3]

[1] The Sylviculture of *Hardwickia binata*, Ind. For. Records, vol. ii, pt. iii, pp. 78, 79.

[2] Ind. Forester, xxxi (1905), p. 380.

[3] Working Plan for the Forests of the Harpanahalli Range, Bellary District, Madras, H. Tireman, 1911.

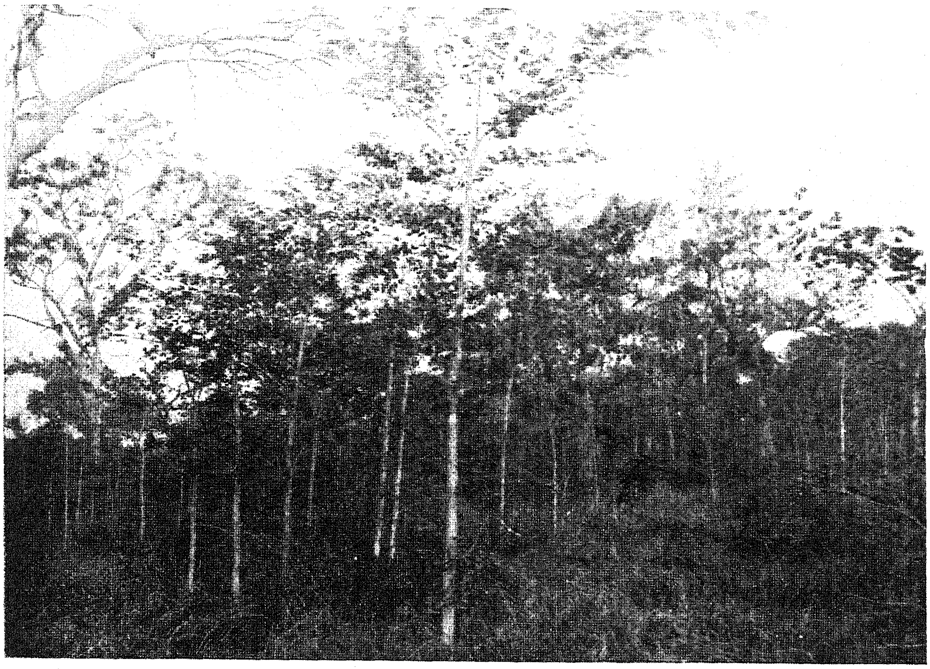

FIG. 138. *Hardwickia binata*, sapling crop on trap, Nimar, Central Provinces.

FIG. 139. *Hardwickia binata*, bushy young growth on a heavily grazed area, Nimar, Central Provinces.

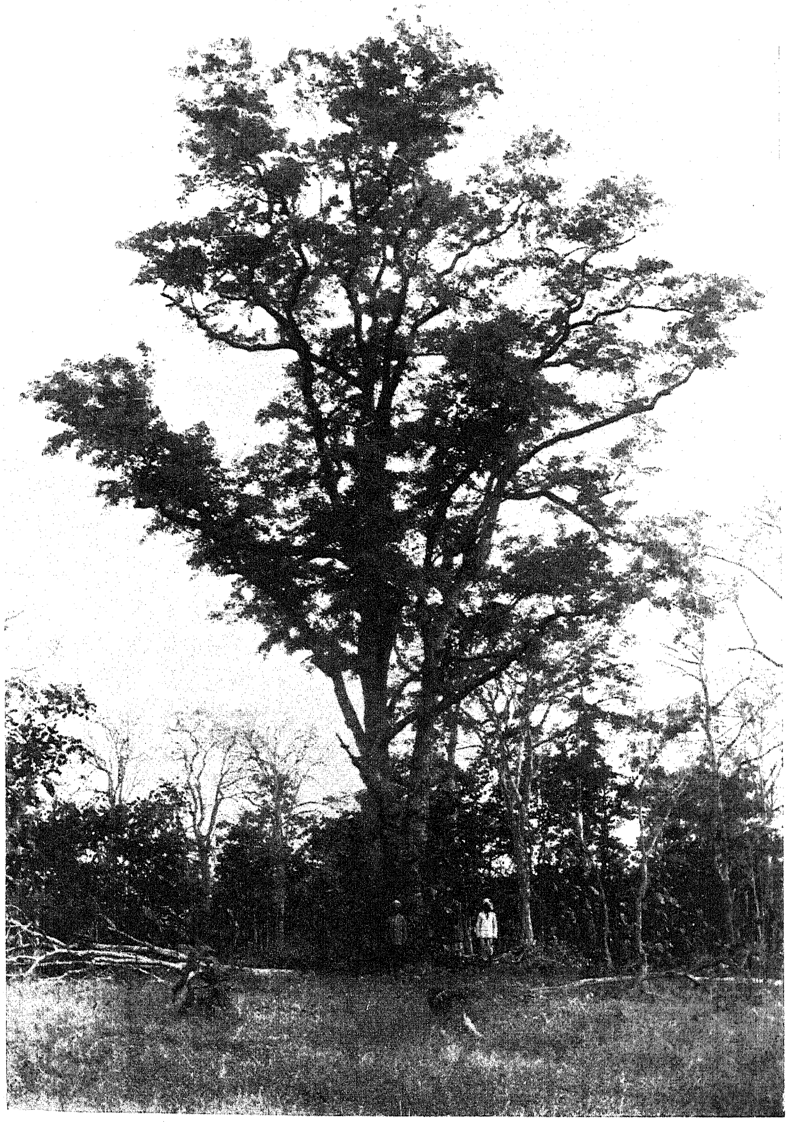

FIG. 140. *Hardwickia binata*, old pollarded trees on sandstone, Nimar, Central Provinces.

Here the trees consist almost entirely of pollards. In the North Arcot district it occurs on the Tirpati and other hills on gneissic rock overlain by masses of quartzite and conglomerate; the soil is usually a red loam with much sand. Here *Hardwickia* is associated with *Pterocarpus santalinus*, *P. Marsupium*, *Chloroxylon Swietenia*, *Terminalia Chebula*, *T. tomentosa*, *Albizzia Lebbek*, *A. odoratissima*, *Dalbergia latifolia*, and other species. In the Salem district it is found in the Shevaroy and Aranuttu hills on gneiss, the soil being a red ferruginous sandy loam. It occurs on rocky quartz soil in Anantapur and on the sandstones and shales of the Palnad in Kistna. In Bombay it is found on sandstone in the eastern part of the Belgaum district.

In the South Chanda district of the Central Provinces *Hardwickia binata* is prevalent on sandy and gravelly soil overlying sandstones and quartzites in the Sironcha range. Here it is essentially a tree of the sandy soils, and attains a girth of 8 ft. It avoids clay unless covered with a depth of sandy débris. In the Nimar district, apart from the trap areas already described, in which, though often remarkably gregarious, it does not attain large dimensions, there is a strip of broken and hilly ground along the Nerbudda occupied by Vindhyan sandstone, conglomerate, granite, schist, and limestone. The overlying soil is sandy or gravelly, and though as a rule by no means deep, it is porous, while the underlying rock is much fissured. On this tract, comprising the Punasa and Chandgarh ranges, *Hardwickia* is never pure, but is always mixed with other species, seldom forming more than 5 per cent. of the growing stock. The development of the individual trees, however, is here excellent, mature trees with a height of 80–100 ft., a girth of 6–10 ft., and a clean cylindrical bole of 40–50 ft. being by no means uncommon. As regards natural reproduction, a distinction has to be drawn between the forest on the hard crystalline Vindhyan sandstones, which disintegrate with difficulty and have a shallow covering of soil, and the more loose-structured conglomerates and shales, which disintegrate readily and produce a fair depth of porous soil, in that the tree regenerates as a rule more freely on the latter.

Hardwickia binata thrives in a dry climate characterized by a long period of drought, scanty to moderate rainfall, and intense heat during the hot season. In the cold season frosts occur only in certain portions of its area of distribution, particularly in low-lying places; these frosts are as a rule slight. It may be said that within its natural habitat the absolute maximum shade temperature varies from 110° to 117° F., and the absolute minimum from 34° to 50° F., while the normal rainfall varies from 10 to 60 in.; it appears to thrive best with a rainfall of 20 to 40 in.

LEAF-SHEDDING, FLOWERING, AND FRUITING. The tree is leafless or nearly so for a short time towards the end of the cold season, the new leaves, which are tinged with red, appearing in April; in the hot weather the trees are in leaf, and their feathery foliage is conspicuous when most other species are leafless. Mr. Witt[1] draws attention to their habit of shedding branchlets: 'Towards the end of the season of growth, about March, a portion of the year's growth is shed, much in the same way as leaves are shed. . . . In April and May the ground under Anjan trees will be found to be littered with small twigs and branches, which at first sight appear to have been broken off, but

[1] *loc. cit.*, p. 101.

a closer inspection shows that they have literally been shed like leaves.' This characteristic, which is also seen in *Tamarix articulata*, *Phyllanthus Emblica*, and *Casuarina equisetifolia*, is obviously a xerophytic adaptation, and the probable explanation of the phenomenon is that the tree endeavours to protect itself from the rigours of the dry season by shedding the less completely lignified and therefore more sensitive portions of its branch-system.

The small pale yellowish green flowers, in axillary and terminal lax panicled racemes, appear from July to September, and the pods develop rapidly, reaching full size early in the cold season and ripening the following April or May. The pod (Fig. 141, *a*) is flat and samaroid, 2–3 in. by 0·4–0·6 in., oblong lanceolate, coriaceous, narrowed at both ends, with parallel longitudinal veins, containing one seed near the apex. The pod dehisces at the apex after it reaches the ground, when germination takes place. The light winged pods commence falling early in May and are often carried to some distance from the parent tree by the strong winds which are prevalent at that season: in full seed-years the ground to the leeward of the seed-bearers is often thickly strewn with pods.

The seed is exalbuminous, flat, averaging 0·8 by 0·3 in., sub-reniform, pointed at one end and rounded at the other, with a fairly hard testa. Fresh ripe seed has a high percentage of fertility, and germinates readily with moderate moisture. It is sometimes said that the seed will not retain its vitality for a year, but instances are recorded in which it has remained fertile to some extent for one or even two years. Thus, 'Yepi seed kept over from 1908 was tried in 1909 with some success', but only 20 per cent. germinated.[1] Again, Shyam Sunder Lal, Assistant Conservator of Forests, Indore state, writes:[2] 'We have sown one-year-old seed in the arboricultural nursery, which germinated fairly well, and the young plants were later transplanted to roadsides in Indore and are quite healthy.' Finally, in patch sowings carried out in 1912–13 in the Saugor division, Central Provinces, seed two years old and not very good germinated satisfactorily in 338 patches out of 1,200.[3]

The tree seeds sporadically to some extent every year, but gregarious seeding takes place on an average every three to five years according to locality. The local extent as well as the periodicity of general seedings varies, and a good seed-year in one locality need not necessarily be a good one in another. When a general seeding takes place the crop of seed is often profuse, the trees being laden with pods. The precise cause of gregarious seeding of this kind is not entirely clear, but there is a presumption, borne out to some extent by meteorological statistics, that it is induced by a season of drought the year before the seeding. The following records of seed-years are available: Nimar, 1874, 1879, 1884, 1889, 1893, 1899, 1905, 1911; Kurnool, 1902, 1905, 1908, 1912; Khandesh, 1908, 1911.

GERMINATION (Fig. 141, *b–g*). Epigeous. The apex of the pod dehisces slightly and the radicle emerges, developing rapidly into a taproot. The cotyledons expand and turn green, extricating themselves from the testa and the pod; they remain only just above ground-level. The pod and the testa are left on the ground.

[1] Working Plan for the Yerramalais, W. Kurnool, 1913.

[2] Ind. Forester, xxxvii (1911), p. 65.

[3] Forest Administration Report, 1912–13.

FIG. 141. *Hardwickia binata*—SEEDLING × $\frac{1}{2}$

a—Fruit b - g—Germination stages h, i—Development of seedling during first season

(Note. On poor dry soil the taproot may attain a considerably greater length.)

THE SEEDLING (Fig. 141).

Roots: primary root long, thin, terete, tapering, wiry: lateral roots moderate in number, short to moderately long, thin, fibrous, distributed down main root. *Hypocotyl* distinct from the root, 0·2–0·3 in. long, thick, fleshy, tapering downwards, glabrous, subterranean or at ground-level. *Cotyledons* on short thick petioles less than 0·1 in. long: lamina 1·1–1·5 in. by 0·5–0·9 in., thin, somewhat fleshy, elliptical oblong or obovate, apex broad rounded truncate or retuse, base sagittate, entire, glabrous, yellow turning green, surface irregularly depressed. *Stem* erect, terete, zigzag at the nodes, slender, wiry, glabrous, green, young parts red; internodes 0·2–0·7 in. long. *Leaves* alternate, bifoliate, at first small, the size increasing with successive leaves. Stipules up to 0·25 in. long, ovate falcate, apex acute acuminate or rounded, pale green turning brown. Common petiole 0·2–0·6 in. long, terete, wiry, glabrous, green, that of young leaves red. Leaflets sub-sessile, 0·5–2·5 in. by 0·3–1·5 in., obliquely ovate or obscurely trapezoidal, apex rounded, base obtuse, entire, coriaceous, glabrous, darker above than below, young leaves red, arcuately 4- or 5-veined from the base.

Mr. Witt [1] has recorded the results of observations on the development of natural seedlings on a plot of ground at Khandwa in Nimar, where the normal rainfall is 30 in., and the seedlings grew on dry sandy soil 6 to 18 in. deep overlying hard *murram* soon passing into solid trap rock. These observations show that the seedlings, like those of the sal and of certain other species in dry localities, die back annually for a series of years, the taproot gradually developing until it reaches the moist layers of the subsoil and establishes itself sufficiently to produce a permanent vigorous shoot which does not die back. These observations indicate the following to be the stages of development of a normal seedling in its natural habitat:

First season. After germination, which takes place with the first heavy downpour of the monsoon proper towards the end of June, the taproot develops rapidly, attaining a length of about 5 to 6 in. within a week, the stem having two leaves almost fully formed. One month from germination the taproots of seven seedlings were dug up and found to vary from 8·38 to 16·1 in. in length: an eighth seedling had a damaged taproot 6·5 in. long. A typical seedling had four leaves fully developed and a fifth commencing to appear. There is little or no development above ground after August, the normal seedling by the end of the first season attaining a height of 5 to 6 in. with about nine leaves, while the taproot ordinarily reaches a length of 12–20 in., or even as much as 3 ft. or more if the depth of the soil permits. In this connexion 'Old Ranger' [2] writes: 'I have found young seedlings, of 6–9 months growth and only 3–4 in. high, the possessors of taproots 22–28 in. long (actual measurements), the almost complete absence of side shoots being very noticeable.'

The taproot shows wonderful power of penetrating hard ground and piercing what appears to be almost solid rock; on shallow soil it twists and turns in search of fissures. By the middle of October the seedlings commence to die back, and by the middle of March, or February in dry seasons, not a single green seedling is to be found, the stems all having died back partially or completely though the taproots remain alive.

Second season. With the following rainy season the seedlings come into

[1] *loc. cit.*, pp. 89–100. [2] Ind. Forester, xxxi (1905), p. 698.

life again, sending up new shoots from dormant buds at the points marking the axils of the cotyledons or from buds on the main stem if the latter has not been completely killed. The second year's shoot is even smaller or more weakly than that of the first year, the plant's energies being concentrated on developing its root-system. On shallow soil the taproot does not develop greatly in length, but thickens somewhat, and there is a marked diminution in the number of lateral roots. Dying back occurs again at the end of the second season.

Third and subsequent seasons. In the third season a new shoot is produced from the root-collum, neither larger nor more vigorous than that of the second season. Meanwhile the taproot develops slowly in length and thickens considerably. The annual dying back of the stem and gradual development of the taproot continues year after year for an unknown period, which Mr. Witt estimates at not less than ten years, the portion above ground gradually developing into a many-branched bush 12–18 in. high. A marked change then takes place: dying back ceases, and a leading shoot forms and grows up at the rate of about 1 ft. or more annually. By this time the seedling may be said to have reached the sapling stage, and the taproot has now become much thickened, with a length up to about 8 ft., the length varying with the depth of the soil: in shallow rocky soil the taproot is much twisted. At the commencement of the sapling stage a natural plant, especially in areas subject to grazing, usually consists of a bushy and many-branched base, from the centre of which rises the leading shoot. As the sapling increases in height the bushy growth at its base gradually dies off, and by the time the plant is 10 ft. high it has disappeared altogether. Each year's growth in the sapling is marked by slightly raised annular marks. These are due to the fact, already noted, that a portion of each year's shoot is shed at the end of each season; a scar is thus formed, on the surface of which develops a bud which produces the following year's shoot. The annular marks represent the scars formed in this way.

The phenomenon of dying back on the part of natural seedlings has been recorded by previous observers in other localities. Thus Mr. E. D. M. Hooper, writing in 1903, mentions its habitual occurrence in the dry districts of Madras where the tree grows, and attributes it partly to fire and partly to the excessive heat of the dry season, and he mentions also the bushy form of growth which this dying back produces until a definite leading shoot is formed.[1] Mr. L. S. Osmaston [2] estimates the period of dying back at four to seven years in West Khandesh.

The phenomenon of dying back, however, is not necessarily universal, for under favourable conditions the seedling may shoot up without any check. Thus Mr. Hooper observes that occasionally under favourable circumstances a patch of young seedlings from its earliest life grows without hindrance, and notes having seen a plant grown on prepared soil at Nagpur on a trap ridge which in one season was over 5 ft. in height. Again, in patch sowings of 1911 in the Saugor district, Central Provinces, some of the seedlings are reported to have reached a height of 3 ft. in three years. Nursery plants at Dehra Dun, kept weeded and watered, reached a height of 6 to 14 in. by the end of

[1] Ind. Forester, xxxi (1905), p. 104.

[2] *Ibid.*, xxxv (1909), p. 381.

the first season and a maximum height of 2 ft. 6 in. by the end of the second season, no dying back having taken place. It follows, therefore, that the habit of dying back is not innate in the species, any more than it is in the sal, teak, and many other species which die back under conditions sufficiently far removed from the optimum.

In other respects also it will be interesting to compare the habits and requirements of the seedling in its natural habitat, as observed by Mr. Witt in Nimar, with those which have been observed in twenty-one experimental plots at Dehra Dun, where, however, the climatic conditions are very different from those prevailing in the natural habitat of the tree, the normal rainfall being 85 in. and frost being at times severe. It goes without saying that for practical purposes a study of the habits and requirements of the seedling in its natural home is of infinitely greater importance than if these are observed under very different conditions, but the results obtained in the latter case are certainly interesting, for though in some respects they differ from Mr. Witt's observations, as might be expected, in others they corroborate them. The conclusions regarding the habits and requirements of the seedling, based on observations made under various conditions, may be summarized as follows :

Root-system. The development of the taproot under natural conditions has already been described. At Dehra Dun the root-system showed a tendency to strong development, even where regular watering was carried out ; this development extended to the lateral roots and was not confined to the taproot as in the case of natural seedlings. By the middle of the second season nursery plants had taproots up to 2 ft. 6 in. in length and 0·7 in. in diameter, with lateral roots up to 1 ft. 7 in. in length.

Drought. In the natural habitat of the species the seedlings are very sensitive to drought, as has already been explained in describing the phenomenon of dying back. This fact has been corroborated again and again by different observers, and it may be said without question that the great mortality noticeable among the numerous seedlings which appear after a good seed-year is due to drought, the excessive heat combined with desiccating winds producing a degree of transpiration which the root-system in the parched soil cannot make good. Even at Dehra Dun many seedlings were found to die down partially or wholly in sunny situations from April onwards.

Frost. In the natural habitat of the tree frosts are not severe enough to do the seedlings any harm, and Mr. Witt notes that he has never observed a single case of a seedling having been damaged in the slightest degree by this agency. At Dehra Dun the frost was found to be severe enough to kill back seedlings of the first year either partially or down to ground-level ; they had good power of recovery, however, and invariably produced new shoots. From the second year onwards they proved to be immune from injury by ordinary frosts.

Shape and development. The shape and development of the seedling under natural conditions has already been described. At Dehra Dun some of the seedlings commenced branching in the first year, while those which had been affected by frost or drought assumed a bushy growth in the second season, with long and rather straggling branches. Growth continued until December, all the leaves had dropped by the end of February, and the new shoots appeared

in March. The young leaves were reddish in sunny situations, and usually green in shady situations.

Damp. At Dehra Dun seedlings proved to be very sensitive to damp, numbers rotting off during the first season even in open nursery beds where watering was done too freely; in the shade hardly a single seedling survived the damp of the rainy season. This corroborates the statement of 'Old Ranger',[1] who writes: 'So sensitive are the *very* young seedlings to excessive moisture that, if seed be sown in a pot containing leaf mould or rich soil, and this be allowed to get a little too damp, the thick fleshy cotyledons of the young seedlings are immediately attacked by rot, which extends downwards to the roots, and a whole pot of young seedlings may thus be destroyed in a single night.'

Effect of grass and weeds. Various opinions have been recorded from time to time as to the effect of a soil-covering of grass on the development of the seedling. According to one theory, the extensive mortality among natural seedlings is due to the inability of the taproots to penetrate the matted roots of the grass. This explanation can hardly be accepted universally, as the degree of obstruction caused by the grass roots must vary, while the roots of *Hardwickia* seedlings have considerable power of penetrating obstructions. The effect of a matted growth of grass roots in preventing soil-aeration, however, may be of importance, and will be considered below under 'natural reproduction'. There is little reason to doubt that the development of the seedlings may be hindered or even entirely prevented from this cause, but on the other hand Mr. Witt[2] has proved by means of experimental plots that the very existence of the seedlings in their natural habitat may depend largely on the protection from the heat of the sun which is afforded them by a soil-covering of grass. His conclusions are summarized as follows:

(1) Grass, as such, does not hinder germination; (2) seedlings may fail to survive on soil quite free of grass; (3) the taproot is quite capable of penetrating through any obstruction of grass roots; (4) the first season of growth is the crucial one in the life-history of the seedling, the mortality being then heaviest; (5) seedlings on soil clothed with grass retain their leaves for a longer period than those on soil not so clothed; (6) the shoots of seedlings protected by a long growth of grass do not dry up so early as those from around which (though on precisely similar soil) the protecting grass covering has been cut away; (7) seedlings up to an age of $3\frac{1}{2}$ years are not smothered and killed by a dense growth of grass weighing down on them; (8) the removal of a covering of grass, from seedlings which have developed under its protection, may be distinctly harmful.

In the damper climate of Dehra Dun, on richer soil with a more luxuriant covering of grass and weeds, experimental plots demonstrated that such a soil-covering not only has a very deleterious effect on the development of the seedling, but is the cause of much mortality through suppression and through the damping off of the seedlings in the rains. These plots also showed clearly that regular weeding has a most beneficial effect on the development and survival of seedlings provided the weeding is carried out from the commencement; on the other hand, the sudden removal of grass and weeds from

[1] Ind. Forester, xxxi (1905), p. 697. [2] *loc. cit.*, pp. 121–6.

around seedlings which have grown under them is very liable to cause the death of the seedlings through desiccation.

The following particulars of seedlings grown under different conditions in experimental plots at Dehra Dun demonstrate clearly the beneficial effects of regular weeding :

Hardwickia binata : measurements of seedlings in experimental plots, Dehra Dun.

No.	Condition under which grown.	Height of seedlings at end of season. 1st season.	2nd season.	Remarks.
1	In nursery beds, watered and weeded	0 ft. 6 in.– 1 ft. 2 in.	Maximum 2 ft. 6 in.	
2	Broadcast sowing, irrigated, weeded	Maximum 0 ft. 10 in.[1]	0 ft. 11 in.– 2 ft. 4 in.[2]	[1] 42 survivors, vigorous. [2] 36 survivors, vigorous.
3	Broadcast sowing, irrigated, unweeded	Maximum 0 ft. 4 in.[3]	0 ft. 3 in. and 0 ft. 4 in.[4]	[3] 8 survivors. [4] 2 survivors ; rest killed by suppression of grass and weeds 1½ ft. high.
4	Broadcast sowing, unirrigated, weeded.	—	0 ft. 7 in.– 2 ft. 0 in.[5]	[5] 20 survivors, vigorous.
5	Broadcast sowing, unirrigated, unweeded	—	0 ft. 3 in.– 0 ft. 4 in.[6]	[6] 4 survivors in poor condition ; rest killed by suppression of grass and weeds.

The observations recorded in Nimar and at Dehra Dun lead to the general conclusion that if moisture conditions are such as to prevent mortality by drought, freedom from grass and weeds, with the attendant loosening of the soil during weeding, is of great benefit as regards the development and survival of the seedling ; but where, as is probably the case in most if not all parts of the natural region of the tree, such moisture conditions do not exist, a soil-covering of grass is of benefit and may be essential for the survival of the seedling, in that it protects it from desiccation. In the latter case, however, it may be presumed, on general principles as well as from the results of the Dehra Dun experiments and of sowings in the Central Provinces and Berar, that the soil-covering of grass must have an adverse effect on the development of the seedling, and that on soil which is loosened and thus aerated better development may be expected, provided the seedling and the soil can be afforded protection by trees, bushes, or otherwise, from the desiccating effects of the sun and dry winds. This question closely concerns the natural reproduction of the species, and will be further alluded to below.

Silvicultural characters. The physical conditions under which *Hardwickia binata* grows in its natural habitat have been dealt with in some detail under distribution and habitat. It may be said in general that the tree thrives in a dry climate and is capable of establishing itself and growing on dry shallow soil and rocky ground where most other species would succumb. This is due partly to the great development of the taproot during youth and its power of penetrating hard soil and fissures in solid rock, the stem usually dying back annually during the development of the taproot, and partly to the fact that the tree stands mutilation better than the majority of species. These facts

no doubt account in large measure for its gregariousness under adverse physical conditions and its survival in spite of continuous maltreatment. The best development is secured as a rule on geological formations such as sandstone, gneiss, conglomerate, &c., which disintegrate into a porous sandy loam, rather than on the stiff and usually shallow soil overlying trap; on the latter formation, however, although development is poorer than on the former, gregariousness is more pronounced.

The great development of the taproot is maintained throughout the life of the tree, as may be observed where the root-system is exposed by scouring along the high banks of streams or the sides of ravines. On shallow soil with compact underlying rock the taproot may assume a gnarled and twisted form, running for some distance horizontally not far below the surface; in such cases the trees are liable to be blown over in high winds.

The tree is capable of standing a certain amount of shade in youth, and even requires shelter in its young stages; later it may be classed as a moderate light-demander or partial shade-bearer, though Mr. Witt states:[1] 'Even the moderate shade afforded by a mature tree of *Boswellia serrata* is too dense for an Anjan sapling to penetrate through, if once dominated. The very flexible yielding shoot of an Anjan sapling may also account to some extent for its inability to pierce overhead cover.' Mr. L. S. Osmaston[2] classes the tree as a partial shade-bearer.

In its natural habitat it is frost-hardy in all stages, being quite unaffected by all ordinary frosts. Except in the seedling stage it is capable of standing great heat and drought. 'This', says Mr. Witt,[3] 'was very noticeable in Nimar during the droughts of 1901 and 1904. Whereas following these droughts such species as *Tectona grandis, Terminalia tomentosa, Lagerstroemia parviflora, Mangifera indica,* and *Buchanania latifolia* suffered severely all over the division, not only coppice being affected but also mature trees, in the case of Anjan no damage whatever was done, even on the driest soils.' The young shoots are sensitive to fire, but the power of recovery is good; ordinarily, seedlings when burnt back send up new shoots from the root-collum, but in severe fires they may be killed outright. Young plants and coppice-shoots suffer much from grazing, the leaves being browsed by deer as well as by cattle and goats; buffaloes especially are partial to them. A grazing incidence which hardly affects a teak forest will prevent young *Hardwickia* plants from making any headway. In heavily grazed areas the plants assume a characteristic bushy form (see Fig. 139).

The tree pollards well even up to a comparatively advanced age, and old pollards when re-pollarded almost invariably produce abundant new shoots: indeed, a special feature of the existing *Hardwickia* forests is the large number of pollarded trees, the result of lopping for fodder and manure (see Fig. 140). On the other hand, the tree coppices indifferently. Old trees which send out vigorous pollard-shoots if cut a few feet above the ground produce no coppice-shoots if cut flush with the ground: old pollards when felled at ground-level never coppice. In some localities a moderate amount of success has been attained by felling at 12 to 18 in. from ground-level.

[1] *loc. cit.*, p. 85. [2] Ind. Forester, xxxv (1909), p. 380. [3] *loc. cit.*, p. 81.

Shyam Sunder Lal,[1] writing of coppice coupes in Indore state, notes that stumps of trees felled about 1 ft. from ground-level delayed sending out shoots for several months, a second inspection revealing a larger percentage of success than one made shortly after the felling.

As regards actual statistics, experiments in North Khandesh in 1903 showed that 47 per cent. of felled trees yielded coppice-shoots, the number being two to six shoots per stool and the average height in the first season being 4 ft. The most complete statistics so far recorded, however, are those published by Mr. L. S. Osmaston[2] giving measurements of 877 stumps in fourteen coupes in West Khandesh. The measurements included stumps of varying dimensions from under 2 ft. to over 6 ft. in girth, and of varying heights from under 2 in. to over 12 in. from ground-level: they also embraced coupes felled in years of deficient as well as of ample rainfall.

These measurements gave the following results, which are somewhat surprising:

(1) The height of the stump had no relation to its vitality: actually the percentage of live stumps of each girth class varied from 39 to 50 and averaged 47.

(2) Similarly the girth of the stump had no relation to its vitality: the percentage of live stumps of each girth class varied from 41 to 49 and averaged 47.

(3) The rainfall had no effect on the vitality of the stump, the percentage of live stumps being 53 in the case of years of most deficient rainfall and 54 in the case of years of most ample rainfall.

These results confirm the opinion generally held that coppice reproduction cannot be relied on to a sufficient extent.

Mr. H. W. Starte has recorded the result of an experiment in coppicing 10 acres of pure *Hardwickia* forest in North Khandesh. Out of 886 stumps varying in girth from 12 to 70 in., cut flush with the ground, the number which failed to coppice was 201, or 22·4 per cent.; there was no relation between girth and coppicing power.

The tree reproduces from root-suckers.

Natural reproduction. As already mentioned, the light winged pods ripen in April and May and fall in the latter month, being often carried to some distance from the trees; in good seed-years they are plentifully scattered over the ground. Germination takes place soon after, with the first heavy downpour of the monsoon, and seedlings may be found in quantity during the rainy season. From October onwards, however, the seedlings die off in large numbers, this mortality being due to drought: under favourable conditions it may consist of dying back with subsequent recovery, but where the seedlings have not had the advantage of protection from the hot sun they may be permanently killed off in large quantities and the seed-crop may result in complete failure. Assuming, however, that a certain number survive, their establishment and further progress until they reach the sapling stage is a matter of time owing to the annual process of dying back described above. A good deal of evidence is available regarding the factors which assist or retard natural

[1] Ind. Forester, xxxvii (1911), p. 63. [2] *Ibid.*, xxxvi (1910), p. 356.

reproduction, but in some respects this evidence is very conflicting, and it will be well therefore to examine it under the following heads:

(1) Effect of grass and weeds; (2) Fire and grazing; (3) Soil conditions; (4) Protective shade; (5) Climatic factors.

1. *The effect of grass and weeds* on the development of the seedling has already been discussed at some length, and it may be concluded that whereas in dry regions a soil-covering of grass assists materially in and may be essential for the establishment of natural reproduction, on the other hand where the grass is too luxuriant it may cause the death of the seedlings through suppression or through rotting off. The beneficial effects of a covering of grass in dry localities have been proved conclusively by Mr. Witt's experiments in Nimar, while Mr. L. S. Osmaston [1] says of seedlings in Khandesh that they do not mind grass even if it be 2 or 3 ft. high. Again, in Anantapur natural reproduction is reported to be good in open grassy areas.[2] Mr. H. F. Arbuthnot,[3] writing of the Malahanagadi block, Bellary, says: 'This block is an interesting one, as it has been under special protection from grazing, cutting, and fires for the last twenty-five years. The result has been that most of the area, which was then presumably blank, has been stocked with *Hardwickia binata*, which is the principal species of the block.' Other instances might be quoted of the beneficial effects of a protective soil-covering of grass, but these will suffice.

On the other hand, there is much evidence regarding the adverse effects of such a soil-covering. Thus Mr. J. Dodgson [4] writes: 'On account of the seed of the Anjan being so light it has great difficulty in reaching the soil through the matted growth of grass, &c., and in this way much of the seed-crop is wasted.' This accords entirely with my own observations in the case of other winged fruits (e.g. *Pterocarpus* spp.). As regards the suppression of those seedlings which do succeed in passing the germinating stage, Mr. S. Srinivasulu Naidu [5] remarks that the heavy grass undergrowth which is common on the trap areas in Buldana probably accounts for the failure of seedlings to establish themselves owing to the smothering action of this growth. A very definite opinion on this point is expressed in the following extract from a report by Mr. L. K. Martin, quoted in the Berar Forest Report for 1903–4: [6]

'The Anjan seeded very fairly profusely in the spring of 1902, and the seed germinated freely during the following monsoon along the Ajanta Hills, especially in the Geru-Matargaon Range around Botha and Matargaon. A very noticeable feature was the complete absence of seedlings from the midst of dense grass, that is, from areas entirely closed to grazing. They appeared wherever the grass was light, and increased in numbers with decrease in density of the grass, till over areas free of grass the seedlings were quite dense.

'The above was most noticeable round Matargaon. There in one and the same ravine the climatic factors are presumably everywhere identical, and the fertility of the soil can hardly vary much over localities only a mile apart

[1] Ind. Forester, xxxv (1909), p. 380.

[2] Madras Forest Report, 1913–14.

[3] Ind. Forester, xxx (1904), p. 123.

[4] Working Plan for the Anjan and Scrub Jungles of the Malegaon, Baglan, Kalvan, and Chandwad Ranges of the Nasik District, Bombay, 1906.

[5] Working Plan of the Buldana Forest Division, Berar.

[6] Cf. Ind. Forester, xxxi (1905), p. 105.

(at any rate they appear to me to be similar). In the portions of the reserve closed to grazing, and consequently covered with a dense crop of grass, anjan seedlings were completely absent, except just along roadsides, whereas in Survey Numbers 1, 2, 3, and 6 of Chinchkher, which were open to heavy grazing and, being situated close to a public road, were much resorted to by cattle and as a result absolutely clean grazed, thousands of seedlings have sprung up and stand out uninjured and perfectly healthy. The above appears to prove conclusively that a dense growth of grass is inimical to the successful reproduction of anjan. The seedlings observed in those Survey Numbers have survived the past two hot weathers and escaped injury from cattle during the same period, when in the absence of other fodder cattle might have been expected to browse them off; grazing throughout the year must obviously be looked upon as a distinct advantage, in fact a real necessity.'

In addition the Dehra Dun experiments described under 'the seedling' above afford conclusive proof that where the rankness of the grass is sufficient heavy mortality may be caused through the damping off of seedlings during the rains: it should be remembered, however, that these possibly represent an extreme case of moisture seldom, if ever, met with in the natural habitat of the tree.

So far as the evidence goes, it may thus be concluded that whereas a soil-covering of grass as a protection against the heat of the sun may be an invaluable factor in the establishment of natural reproduction, under certain conditions it may become noxious, preventing the germination of seed and the establishment of seedlings owing to its rank growth; the precise conditions under which its influence is beneficial or the reverse have not yet been determined.

2. *Fire and grazing.* The direct effects of fire and grazing are, with good reason, generally held to be highly prejudicial to natural reproduction, for although the power of recovery of the seedling from injury from these causes is higher than that of many other species, great damage is suffered in unprotected areas, and reproduction is much retarded. Much evidence has been recorded in proof of this, and it will suffice to quote only a few instances. Mr. G. S. Hart[1] notes regarding Nimar: 'At present the number of Anjan seed-bearers in these forests is often small, but the natural regeneration of this species in all closed areas is excellent and is not confined, as in the Buldana district, to small seedlings, the majority of which cannot be considered as established.' Of the same forests Mr. C. F. Bell[2] writes: 'The hot weather kills out a large percentage of seedlings and over-grazing in the open coupes and grazing blocks completes the destruction. In coupes worked over and then closed to grazing for ten years, however, a fair number of seedlings have established themselves, and the future prospects of the crop are promising.' Again, Talbot[3] states: 'Owing to sheep and cattle grazing, reproduction by seedlings over large areas in Khandesh and Nasik is much impeded. Multiplication of the species by root-suckers is, however, general and there appears little danger of the valuable Anjan disappearing from any of the areas of its distribution.' Finally, Mr. J. Tapp[4] writes regarding West Kurnool: 'Natural

[1] Inspection Note on the Nimar Forest Division, 1911.
[2] Working Plan for the Reserved Forests of the Nimar District, Central Provinces, 1913.
[3] Forest Flora of the Bombay Presidency and Sind, i. 457.
[4] Working Plan for the Yerramalais, West Kurnool, 1913.

reproduction has hitherto been very poor, but since lopping of Yepi trees for fibre has been put a stop to and fire protection introduced natural seedlings of Yepi are beginning to come up in many of the reserves.'

On the other hand, instances may be quoted where fire and grazing have not had the adverse effects which they might be expected to have. Mr. Martin's report, just quoted in connexion with the effects of grass, would indicate that where there is a sufficient supply of palatable grass the seedlings may escape injury, and even benefit by the partial removal of the grassy covering; without further evidence of a similar nature, however, it would be unsafe to generalize on the results of this particular case. The same may be said of the results attained by Mr. H. L. Newman in experimental plots in East Khandesh in 1908, though these results, which are quoted in the Bombay Forest Report for 1908–9, are interesting so far as they go. The object of these experiments was to ascertain the percentage of mortality among natural seedlings in thirty-one different patches. Several of these patches were accidentally burnt and others were purposely burnt in the dry season following the seeding; the results showed a larger percentage of survivals in the burnt than in the unburnt plots. Protection from fire and grazing may have an adverse effect under certain conditions in inducing a rank growth of grass.

3. *Soil conditions.* Under natural conditions the degree of soil moisture necessary for the normal development of the sapling is not ordinarily attained until the taproot has penetrated some distance into the subsoil, and hence the annual dying back of the stem, which has already been described. It is generally agreed that the shallower the soil and the harder and more impermeable the subsoil the more difficult it is for the seedling to establish itself, the progress of the taproot being slower and the period during which the plant is exposed to the risks of desiccation being longer. Conversely, it might be expected that anything which will tend to increase the porosity of the soil or prevent desiccation will materially assist in the establishment of the seedling; and there is ample evidence to prove that this is the case. To begin with, the Dehra Dun experiments described above clearly demonstrate the beneficial effect of regular weeding in stimulating the development of the seedling, this stimulus being due, in the earlier stages at all events, at least as much to the loosening of the soil as to the actual removal of weeds. Soil-aeration of this kind is now an accepted factor in the case of plant growth, not only providing a supply of air to the roots, but also furnishing an air-cushion which conserves the soil-moisture and prevents desiccation. In the dry regions in which *Hardwickia binata* grows it is of special importance, and there is no lack of evidence to show that loosening the soil has assisted in establishing reproduction. Thus the abundance of natural reproduction on abandoned cultivation has been commented on on more than one occasion, while there are numerous instances of seedlings establishing themselves readily on hoed ground on which seed has been sown. Mr. E. E. Fernandez has recorded some interesting observations bearing on this subject in an article entitled *The Treatment of Hardwickia binata*,[1] from which the following quotations, relating to the Nimar district, are taken: 'Up to the reservation of Punasa . . . every attempt . . . had been made to get rid of the forest and replace it by field crops, but the

[1] Ind. Forester, xxix (1903), p. 517.

forest reappeared almost as fast as it was destroyed. . . . The ground was never completely cleared of forest; numerous trees of seed-bearing age were left scattered all round and over the fields. The seed fell from these trees on the newly broken land, now at last also freed to a great extent of grass, and the resulting seedlings came up under the most favourable condition for survival. The subsequent cultivation of the soil, limited to a mere scratching of the soil, left an appreciable proportion of the seedlings uninjured to continue their development, and as the field was abandoned as soon as the soil showed the first signs of exhaustion, the young plants were left in complete possession of the ground. . . . During the seven years that I was able to continue my observations before I was transferred to the United Provinces the seedlings of pre-reservation days continued to strengthen themselves and develop, but no new contingent of seedlings survived to swell their numbers. . . . The seedlings are as usual produced in countless numbers after every periodic gregarious seeding, but, being unable to push their taproots down deep enough, they all perish in their very first year.' Again: 'There is no doubt whatsoever that the death of the seedlings is due to their inability to force their long slender taproot down deep enough through the matting of grass roots occupying the soil everywhere to a depth of 1–2 ft.'

We have already seen that Mr. Witt's experiments appear to disprove the theory that the taproots of the seedlings are unable to force their way through the roots of the grass, and to show that the mortality among the seedlings is due to drought. At the same time, the observations of Mr. Fernandez indicate that seedlings appearing on land which has been broken up for cultivation and subsequently 'scratched' for a few years have succeeded in establishing themselves, whereas in the same locality seedlings appearing on land which has reverted to grass have failed to do so. This affords room for a strong presumption that success in the former case was due to soil-aeration, and that Mr. Fernandez was not very far wrong in attributing failure in the latter case to the grass roots, though the failure was probably due not so much to their direct obstructive action as to the introduction of an unfavourable factor possibly connected with deficient soil-aeration, caused, in part at least, by the binding action of the roots.

To quote further examples of establishment of reproduction on broken soil, Shyam Sunder Lal[1] writes of conditions in Indore state: 'The natural seed regeneration in the seeding year (which is generally every third year) is so profuse, that many thousands of small seedlings per acre can be counted in the forests. A large proportion of these, however, die from several causes, but this kind of regeneration, on old sites of cultivation, has always been noticed to thrive extraordinarily, and it is an object lesson to be remembered that breaking up of land in the vicinity of anjan seed-bearers, either by means of ploughs or otherwise, helps the young seedlings considerably and gives much better results. . . . This has been tried in our forests with good results.'

Mr. P. M. Lushington,[2] referring to a remarkable plot of natural reproduction in the Malappakonda reserve, Anantapur district, which is known to have come up within recent years near old seed-bearers on cultivated land acquired at settlement, remarks: 'A lesson can I think be learned from this

[1] Ind. Forester, xxxvii (1911), p. 65.

[2] Inspection Note, 1913.

area, that we can aid the regeneration of this valuable species in places where there is a reasonable amount of soil by merely ploughing it up in the vicinity of existing trees.'

Mr. S. Srinivasulu Naidu[1] writes of experiments in Buldana: 'In the Moegaon felling series of the Amdari Reserve the experiment consisted in closing the area to grazing and breaking up the soil for a radius of fifty feet round a number of marked seed-bearers in a forest which had been subjected to heavy grazing and in which natural regeneration was practically absent at the time the experiments were started. The sample plots are situated close to the Buldana-Malkapur road and the grass in the locality is cut over once or twice in the year. Some of the sample plots have been specially kept clear of heavy grass by weeding, while others have been left without treatment, but in both cases the results are generally satisfactory and often excellent.'

Mr. L. S. Osmaston[2] notes with regard to Khandesh: 'Although anjan often reproduces itself well by seed naturally, still such reproduction is considerably helped and better ensured by breaking up the soil under a seeding tree; on such broken up soil the seedlings are not only more numerous but better grown, more vigorous and more likely to withstand the first hot weather than those on unbroken ground.'

4. *Protective shade.* The value of protective shade has already been indicated in connexion with the dying of seedlings through drought and the beneficial effect of the protection afforded by grass in dry localities. We have, however, already seen that there is a strong presumption that in certain cases a growth of grass may produce adverse soil conditions sufficient to counterbalance the beneficial effects of the grass, and it remains to be seen if any other form of protection is likely to secure the establishment of natural reproduction. As far as is known there are no records of definite experiments to ascertain the effect of the protective shade of trees and bushes and how this shade should be applied. There are, however, suggestions and observations which may be quoted. Thus, in 1903, Mr. T. B. Fry[3] suggested the open condition of the forests in Bombay as one possible cause of mortality among seedlings, and thought something might be gained by introducing nurses to protect the young plants from the fierce heat of the sun. Mr. Witt[4] states: 'From observations made, we are strongly of opinion that shade as a protection to seedlings during the first three or four years' growth, against the heat and the dry winds of the hot season, is a *sine qua non* in the successful regeneration of anjan forests.' And again:[5] 'The more the seedlings are exposed to the direct rays of the sun and the scorching hot winds of the dry season the more will they transpire, and the more moisture will they require. Consequently, if in addition to the protecting growth of grass the seedlings also have overhead cover, we might expect it to act in a similar manner. And this is exactly what we have observed. Wherever the seedlings have been protected by a growth of grass and overhead shade, they have survived in far greater numbers than those in free and exposed positions.'

Mr. L. S. Osmaston[6] also records the following observations: 'Bushes

[1] Working Plan for the Buldana Forest Division.
[2] Ind. Forester, xxxv (1909), p. 380.
[3] *Ibid.*, xxix (1903), p. 527.
[4] *loc. cit.*, p. 85.
[5] *loc. cit.*, p. 126.
[6] Ind. Forester, xxxv (1909), p. 380.

of *Cassia auriculata*, *Gymnosporia montana*, and *Rhus parvifolia* are of great use in regeneration : it is surprising how many healthy *Hardwickia* seedlings one finds right under the shade of such bushes : this is apparently due to the shelter afforded from the heat of the direct sun's rays and to the fact that under such bushes there is an accumulation of soil and humus ; also where cattle grazing is allowed such bushes protect the seedlings from being eaten. I have not yet come to a conclusion as to whether such bushes should be cut level with the ground when the *Hardwickia* seedlings in their shade have attained a certain age.'

5. *Climatic factors*. We have already considered at some length the adverse effects of drought on the development of the seedling and the establishment of natural reproduction. The factor of rainfall is one which seems to require further study, and in this connexion the following quotation from the Yerramalais working plan [1] is of interest :

'Most of the seedlings die out in the prolonged drought which follows the rains and continues for about nine months. It is only when this drought is interrupted by rainfall that some of them survive. Therefore it is usual to come across a group of young seedlings in one place and a patch several years older at another. For successful regeneration rainfall should be regular or the seedling should be able to pass the strata affected by drought before it is killed.'

The extent and distribution of the seasonal rainfall may very well be presumed to have an effect on the establishment of natural reproduction ; in the absence of direct evidence, however, it seems unsafe definitely to ascribe the establishment of reproduction in patches to favourable years of rainfall, though it is by no means an improbable explanation of the phenomenon.

Conclusions. From the details just given it may be concluded that, given the necessary seed-bearers, factors ordinarily beneficial to the establishment of natural reproduction are porosity and depth of soil, protection in early youth from the heat of the sun, protection from fire and grazing, and probably also favourable rainfall conditions. Adverse factors are stiffness and shallowness of soil, exposure of the seedlings to a hot sun, fire, grazing, and probably adverse rainfall conditions. Under certain conditions a soil-covering of grass may be decidedly beneficial in affording protection from the sun, while under other conditions it may, if sufficiently rank, be a highly noxious factor in preventing the seed from reaching the ground and in suppressing seedlings or causing them to damp off.

There may possibly be other factors affecting the question, but those under consideration give some indication of how natural reproduction may be induced, namely, by ploughing or hoeing up the ground to the leeward of seed-bearers in good seed-years and protecting the resulting seedlings from the heat of the sun. In Nimar, and no doubt in other localities, this protection can be secured, according to Mr. Witt's observations, by allowing the grass to grow up ; under some conditions, however, it may be necessary to keep the soil loose and to clear the grass. In either case the shade afforded by trees and bushes will be beneficial and may even be essential. This last consideration gives a possible clue to the origin of some of the existing crops

[1] Working Plan for the Yerramalais, West Kurnool, J. Tapp, 1913.

of *Hardwickia* in localities where natural reproduction does not appear now; these crops may have come up under the shelter of previously existing trees. On the other hand, it is not improbable that some of them are the result of natural reproduction which appeared on land at one time under cultivation.

ARTIFICIAL REPRODUCTION. *Hardwickia binata* has been propagated artificially to some extent both within and without its natural habitat, partly by direct sowing and partly by transplanting, though it is generally agreed that the former is the more successful. Haines says it has been extensively planted in Nagpur, where it grows well on the trap hills; also that it is best sown *in situ*, and remains very small for the first two or three years. It has been transplanted with success on the Talankheri (Seminary) hill, Nagpur, after pruning the stem and root. In Saugor patch sowings have been carried out with varying success; in some cases the seedlings have attained a height of 3 ft. in three years. Mr. Fernandez [1] says it bears transplanting well, and recommends transplanting superfluous seedlings from patches from the third year onwards, younger plants not being robust enough. This does not agree with my experience at Dehra Dun, where direct sowings were found to be much more successful than transplanting, whether with pruned or intact stem and roots. The difficulty of transplanting is corroborated by Mr. L. S. Osmaston,[2] who writes: 'It is hopeless to try and transplant the seedling, however young the seedling may be: artificial regeneration can therefore only be successful if sowing takes place where the tree is to be permanently. When sowing it is best not to cover the seed with soil at all, or at any rate to only partially cover it.' I have found it advantageous to cover the seed lightly, as this not only prevents it from being blown away but also protects the radicle from the attacks of birds during germination.

The experience of Shyam Sunder Lal regarding transplanting in Indore is, on the other hand, favourable. He writes as follows: [3]

'As regards its suitability for transplanting, I can say with confidence that it transplants as well as any other tree. I have transplanted several hundred small seedlings to fill blanks in the forests and always with good results. In the year 1908 I sent more than a dozen trees, 9 ft. in height, from our forests to the Residency compound at Indore, and every one of these plants is fully established, and out of the two 18-inch girth trees which I had sent to Indore from a distance of 20 miles, one died, the other is perfectly healthy. In the Rajputana-Malwa Railway Executive Engineer's compound at Mhow, several hundred seedlings were transplanted six or seven years back, and these are at present 10 to 12 ft. high and look quite promising.'

In the Yerramalais working plan it is stated that broadcast sowing on ploughed land as well as dibbling have been tried without success, for although germination was good nearly all the seedlings were killed off by drought. The system found most successful is to sow in contour trenches 6 ft. by 2 ft. by $1\frac{1}{2}$ ft., in which the soil at the bottom has been loosened, and on mounds of earth thrown up alongside. The seedlings in the trenches are shaded from December or January until the following rainy season by laying sticks across the trenches and covering them with a thick layer of grass weighted with stones,

[1] Ind. Forester, xxix (1903), p. 527. [2] *Ibid.*, xxxv (1909), p. 380.
[3] *Ibid.*, xxxvii (1911), p. 64.

a length of 1 ft. being left uncovered at the end of each trench to admit light and air.

Various methods of experimental sowing on trap formation in the dry climate of Nasik (rainfall about 24 in.) have been described by Mr. L. S. Osmaston.[1] Dibbling the pods proved a failure. Broadcast and line sowings without preparation of the ground, as well as sowing in pits, were only moderately successful. Mound sowings gave more success, especially in the case of fairly large mounds $2\frac{1}{4}$ ft. high, and 2 ft. and 7 ft. in diameter at the top and base respectively, while broadcast sowings on ploughed ground were decidedly successful, particularly where the ploughing was followed by harrowing to remove the tufts of grass. The greatest success, however, was attained by means of line sowings in combination with the raising of agricultural crops, a method which has generally been found to be the most successful in raising forest plantations in dry regions. These sowings are described in the *Indian Forester*, vol. xxxiii (1907), p. 266. The field crops employed were sesamum, cotton, and the lesser hemp, the sowing being preferably carried out by lessees under a two years' lease. Two separate methods were tried as follows: (1) In the first year the lessee cultivated field crops only, while in the second the tree seeds as well as field crops were sown, the area being weeded twice in the first rains. One line of tree seeds was sown to three lines of field crops, and the lines being about 1 ft. apart the distance between the lines of tree seeds was about 4 ft. (2) The tree seed was sown in the first year of the lease, four adjacent lines of tree seeds (forming a strip 3 ft. wide) alternating with strips of field crops 8 ft. wide; in the second year the lessee cultivated field crops between the strips of tree seedlings and weeded and sowed up blanks in the latter. In departmental sowings of this kind the cost of formation for the first three years amounted to Rs. 28–11–0 per acre and the receipts from the produce of the field crops Rs. 32 per acre, showing a profit of Rs. 3–5–0 per acre.

Similar sowings with field crops in Berar, which have also proved successful, have been described by Mr. C. G. Rogers.[2] The field crops employed were sesamum, cotton, and *arhar*; the *Hardwickia* seedlings reached a height of $1\frac{1}{2}$ to 2 ft. in two years and four months.

SILVICULTURAL TREATMENT. At present *Hardwickia binata* is treated under a variety of methods of working. In various localities the system employed is coppice-with-standards, in which *Hardwickia* constitutes the standards and miscellaneous species the coppice. In the Dhulia and Pimpalner ranges of West Khandesh the treatment prescribed is improvement fellings with artificial reproduction of *Hardwickia* by broadcast and by agri-silvicultural sowings.[3] Similar treatment is prescribed for the Yerramalais, West Kurnool, regeneration being effected by means of trench and mound sowings already described. In Buldana a somewhat similar method of working is in operation experimentally.[4] The treatment consists of the removal, under a felling cycle

[1] Ind. Forester, xxxiii (1907), p. 177. [2] *Ibid.*, xxxvii (1911), p. 8.

[3] Working Plan for the Anjan and Scrub Jungles of Dhulia and Pimpalner Ranges, West Khandesh, J. Hamilton, 1914.

[4] Working Plan for the Buldana Forest Division, Berar Circle, Central Provinces, S. Srinivasulu Naidu, 1913.

of twenty years, of over-mature and deteriorating stems subject to the retention of a minimum of 20 seed-bearers per acre, combined with regeneration by breaking up the soil and sowing broadcast: *Hardwickia* is felled at a height of 18 in. from the ground.

Under 'natural reproduction' (conclusions) and 'artificial reproduction', pp. 357–9, methods are suggested for obtaining regeneration naturally and artificially, and it will generally happen that even if the former is secured it will require to be supplemented by the latter. Important points are the retention of sufficient shade until the young crop is established, protection from fire, and closure to grazing until the saplings are out of reach of animals, that is, usually for ten years or even more.

Rate of growth. The annual rings are not very distinct, but according to Mr. Witt they can frequently be made out with a good lens by the numerous pores filled with resin at the inner edge of the ring. Gamble says the rate of growth is usually about 10 rings per inch of radius, which gives a mean annual girth increment of 0·63 in. In dry localities on poor shallow soil the growth under natural conditions may be extremely slow. Mr. E. D. M. Hooper writes: 'The natural growth of the young tree in the dry Deccan is undoubtedly very slow, and I have watched the species in the Malpangudi and Sherbi reserves of Bellary for the past twenty years and the stems have scarcely progressed.' Trees raised artificially and tended grow much more rapidly. Mr. Ananda Rao [1] says: 'Some planted in the Nandyal compound about twelve years ago are about 25–30 ft. high and about 6 in. in diameter at breast height.'

Allusion has already been made, under 'the seedling', to the fact that the rate of growth of saplings can be traced by the annular marks on the stem, which denote each year's growth. Mr. Witt [2] estimates in this way that the average rate of height-growth of a normal sapling in Nimar, from a height of 3 ft. upwards, is 9–12 in. a year, and that allowing for the period of dying back in the early stages a natural sapling 10 ft. high would be about twenty years old. He also quotes some interesting figures showing the estimated rate of growth of trees on trap and on sandstone respectively. Thus forty-five trees, planted along roads in the civil station of Khandwa on shallow soil overlying trap rock, were thirty-seven years old. Measurements gave the following results:

Average height	35 ft.
Mean annual height increment	9·3 in.
Average diameter (at breast height)	10·1 in.
Corresponding girth	2 ft. 8 in.
Mean annual girth increment (including bark)	0·86 in.
Number of rings per inch radius (after deducting 1 in. thickness of bark)	9 rings

As regards growth on sandstone, ring-countings made by him in respect of ten trees of various ages showed an average of between 13 and 14 rings per inch of radius, representing a mean annual girth increment of 0·46 in.

Mr. A. W. Lushington, quoted by Gamble,[3] says that planted trees of known age on the Kistna canals gave 2·04, 3·23, 4·54, 6·10, 7·35, 8·43, 9·43, 10·39, 11·33, 12·26, and 13·18 in. diameter for 5, 10, 15, 20, 25, 30, 35, 40,

[1] Working Plan for the Yerramalais Hill Reserves, West Kurnool, 1906.

[2] *loc. cit.*, pp. 101–2.

[3] Man. Ind. Timbers, 1902, p. 277.

45, 50, and 55 years respectively. The last corresponds to about 8 rings per inch of radius.

As regards coppice growth, Mr. L. S. Osmaston records the following measurements made in coppice coupes of different ages on trap formation in West Khandesh (rainfall about 20 in.):

Hardwickia binata: number of shoots per stool and growth of coppice.

Age. years.	No. of shoots per live stump.	Mean girth at breast height of largest shoot. inches.	Mean height of largest shoot. feet.
1	2·8	—	1·4
2	3·0	—	1·6
3	2·6	2·0	6·0
4	2·9	2·7	6·7
5	2·6	6·0	11·7
6	3·5	6·8	12·5
7	2·7	6·3	11·1
8	3·3	4·3	9·6
9	2·5	8·0	13·6
10	2·8	8·8	15·0
11	3·2	11·0	17·0
12	3·4	6·9	11·7
13	2·2	9·8	14·5
14	3·4	11·0	13·9

The average number of shoots per live stump in all the coupes is 2·9.

2. **Hardwickia pinnata,** Roxb. Vern. *Madeyan sampirani, koda palei,* Tam.; *Shurali, kiyavu,* Mal.; *Chon paini,* Coorg.

A large handsome evergreen tree attaining a height of 100 ft. and a girth of 14 ft., with dark green shining foliage. Leaves with four to seven leaflets 2–4 in. long. Bark dark brown and green, rather rough. Wood moderately hard, dark red or reddish brown, ornamental, used for building and furniture.

Distribution and habitat. The tree occurs in the Western Ghats from South Canara to Travancore. It is abundant in the forests of Travancore up to 3,000 ft. In Coorg it is common in the evergreen forests: enumerations by Mr. N. E. Shrigley in 1914–15 gave an average per 100 acres of 58 trees above 7 ft. 6 in. in girth, and 22 trees 6 ft. 9 in. to 7 ft. 6 in. in girth. In the Coorg evergreen forests its chief companions are *Hopea* spp., *Dipterocarpus indicus, Vateria indica, Dysoxylum malabaricum, Artocarpus hirsuta, A. integrifolia, Calophyllum* spp., *Dichopsis elliptica,* and *Mesua ferrea.*

Flowering and fruiting. The small white flowers, in dense panicled racemes, appear in February, and the pods ripen in May–June. The pod (Fig. 142, *a*) is 1·2–2 in. long by 0·8–1·2 in. broad, turgid, woody, compressed, with a single seed in the apical part, indehiscent until germination, when it dehisces slightly at the apex.

Germination (Fig. 142, *b–d*). Hypogeous. The pod dehisces slightly at the apex, enabling the radicle and plumule to emerge; these elongate rapidly, while the cotyledons remain within the pod.

The seedling (Fig. 142).

Roots: primary root long, moderately thick, terete, tapering, flexuose: lateral roots few to moderate in number, short, fibrous, distributed down main root. *Hypocotyl* scarcely distinguishable. *Cotyledons* 0·8–1·2 in. by 0·4–0·7 in., fleshy, remaining within pod. *Stem* erect, glabrous or young

parts minutely puberulous. *Leaves* alternate, compound, earlier leaves with one pair, later leaves with two or three pairs of leaflets, first few leaves abortive and scale-like. Stipules up to 0·15 in. long, falcate acuminate. Common petiole (earlier leaves) 0·4–1·5 in. long. Leaflets with thick petiolules 0·1–0·15 in. long, lamina 1·5–3·5 in. by 0·6–1·2 in., obliquely ovate acuminate, entire, coriaceous, gland-dotted, glabrous or lower surface minutely puberulous in young leaves, lateral veins numerous. The seedling ordinarily attains a height of about 8 in. in the first season, with a taproot 1 ft. or more in length.

The growth of the seedling appears to be somewhat slow. Mr. H. Tireman informs me that young plants raised from seed sown in 1914 under moderate shade in an abandoned *kumri* in Coorg had an average and maximum height in January 1918 of 0 ft. 11 in. and 2 ft. 9 in. respectively.

Rate of growth. Bourdillon says that the annual rings are marked by dark lines, and that the rate of growth is about 12 rings per inch of radius, giving a mean annual girth increment of 0·52 in.

5. SARACA, Linn.

Saraca indica, Linn. Asoka tree. Vern. *Asok*, *ashok*, Hind.

Though not an important forest tree, this tree is often planted for ornament or for religious purposes ; it is one of the most sacred trees of the Hindus and Buddhists, the flowers being much used for religious ceremonies and temple decoration. It is found wild along streams, or in the shade of the evergreen forests, in the Khasi hills, Chittagong, Arakan, Tenasserim, Upper Burma, the Northern Circars, and the west coast of Bombay. The clusters of fragrant orange or red flowers appear from January to April or May. The tree is interesting as furnishing an example of drooping young leaves without chlorophyll, like those of certain other evergreen trees, for example *Amherstia nobilis*, *Mesua ferrea*, *Mangifera indica*, *Polyalthia fragrans*, and others. The leaflets of the young leaves are red in colour, thin and flaccid, and hang vertically downwards for some time after attaining full size.

6. AMHERSTIA, Wall.

Amherstia nobilis, Wall. Vern. *Thawka*, Burm.

This, one of the most beautiful flowering trees in the world, is an evergreen tree indigenous in Tenasserim and cultivated in the moister parts of Burma and southern India. The flowers are crimson to yellow or salmon pink, in large candelabrum-like pendulous racemes hanging amongst the handsome foliage. The young leaves are of a rich red or purplish colour and hang flaccid (see under *Saraca indica* above). The tree is somewhat difficult to cultivate, being delicate when young and requiring a rich soil and a warm moist equable climate. It may be raised from seed in pots or baskets, but can best be propagated by layering in the hot season and planting out during the rains. It is cultivated successfully in Ceylon, but seldom ripens its seeds there ; it flowers during the greater part of the year, but chiefly from January to March.

7. TAMARINDUS, Linn.

Tamarindus indica, Linn. Tamarind. Vern. *Imli*, *amli*, Hind. ; *Hunase*, Kan. ; *Chinch*, Mar. ; *Puli*, Tam. ; *Chinta*, Tel. ; *Pulinje*, Coorg ; *Magyi*, Burm.

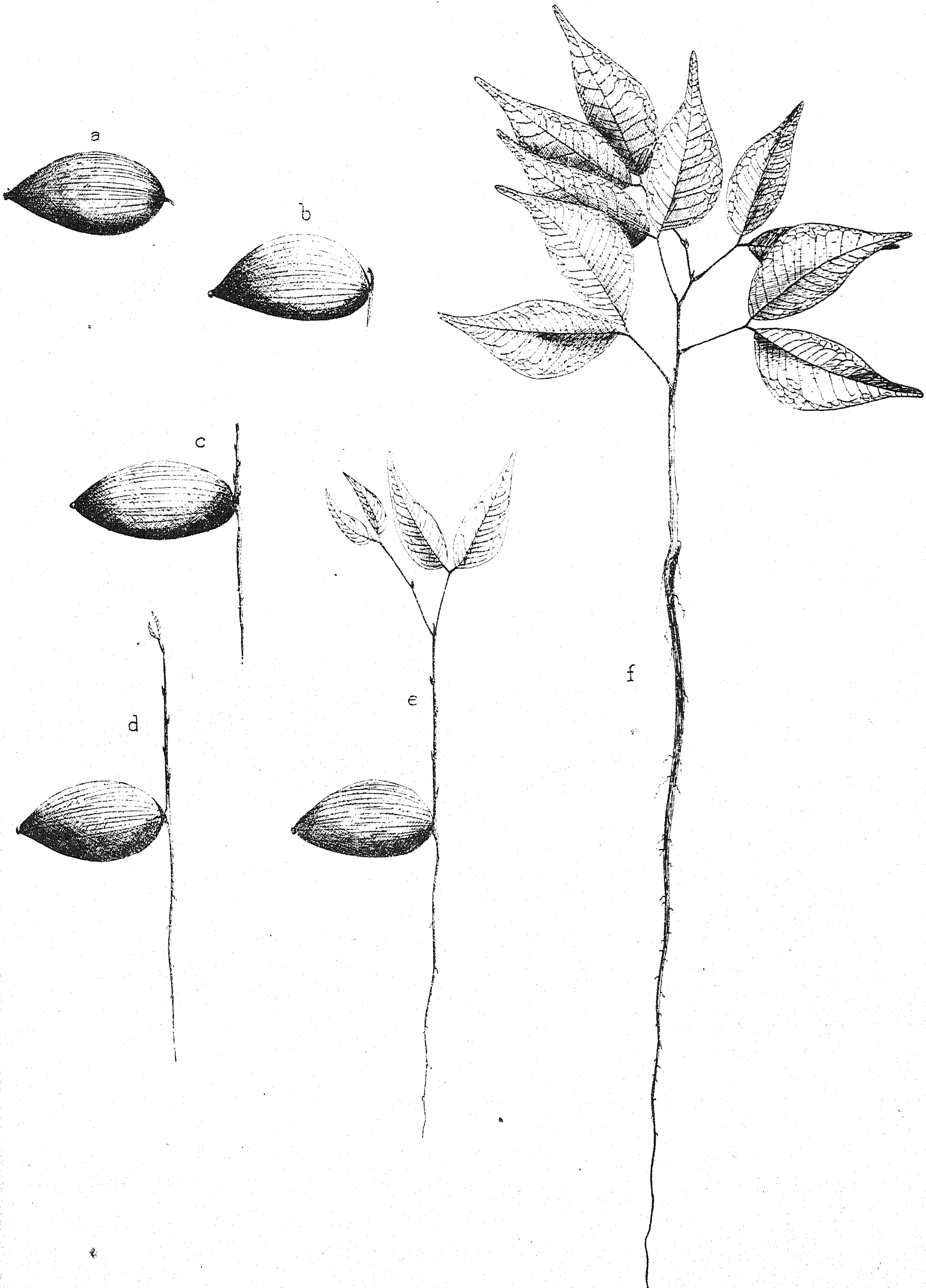

FIG. 142. *Hardwickia pinnata*. Seedling × ½.
a, fruit ; *b–d*, germination stages ; *e*, seedling one month old ; *f*, seedling six months old.

A large usually evergreen tree attaining a height of 100 ft. and a girth of 15 ft. or more, with a spreading rounded crown and pinnate leaves with ten to twenty pairs of leaflets about 0·5 in. long. Bark dark grey, moderately thick, deeply cracked. Wood hard and close grained, used for rice-pounders, oil and sugar mills, tools, furniture, and turnery. The tamarind is not a forest tree, but is largely planted for shade and ornament and for the sake of its pods, which are used as an astringent and aperient and for making condiments. It is an excellent avenue tree, being always in leaf and having a spreading crown. Mr. A. E. Wild records a tree 25 ft. 6 in. in girth at Kara, Gaya.

Distribution and habitat. Said to be indigenous in Abyssinia and central Africa. Largely planted in India along roads and avenues, and in and around villages; frequently run wild. Tamarind groves in the forest often mark the sites of deserted villages. It thrives only in the warmer parts of India, and though planted as far north as the Punjab it does not ripen its fruits, nor does it flourish. In Burma it is one of the commonest of village trees in the dry zone.

Leaf-shedding, flowering, and fruiting. The tree is never leafless except in very dry localities, where it is sometimes leafless for a short time in the hot season. The new leaves appear in March–April. The small yellow and red variegated flowers appear from April to June (also in October, Haines), and the pods ripen from February to April. The pods are brown, 3–6 in. long, 0·5 in. thick, with a brittle epicarp, filled with a dark brown fibrous acid pulp containing three to ten brown smooth compressed seeds (Fig. 143, *a*). The pods are readily eaten by monkeys, which are instrumental in scattering the seeds. The germinative power of the seed is fairly high (average 66 per cent. in tests at Dehra Dun, where conditions are not favourable).

Germination (Fig. 143, *b–e*). Epigeous. The radicle emerges from one end of the seed and descends rapidly. The hypocotyl elongates, arching slightly, and raises above ground the cotyledons enclosed in the testa. The latter falls to the ground when the cotyledons expand.

The seedling (Fig. 143).

Roots: primary root long, wiry, flexuose: lateral roots numerous, moderately long, fibrous, distributed down main root. *Hypocotyl* distinct from and thicker than root, 1·5–3·5 in. long, slightly compressed, finely tomentose. *Cotyledons* sessile, 0·5–0·7 in. by 0·35–0·5 in., plano-convex, thick, fleshy, unequally ovate, orbicular or obovate, apex rounded, base projecting about 0·1 in. behind point of insertion. *Stem* erect, terete or slightly compressed, wiry, tomentose; internodes 0·3–1 in. long. *Leaves* paripinnate, first pair opposite, subsequent leaves alternate. Stipules 0·2–0·3 in. long, falcate acuminate, pubescent. Rachis 1·1–3 in. long, pubescent, terminating in a bristle. Leaflets 6–10 pairs, opposite, sub-sessile, 0·4–0·9 in. by 0·15–0·3 in., linear oblong or rhomboidal, obtuse or slightly emarginate, entire, pubescent, glaucous beneath, darker above.

The early development of the seedling is fairly rapid under favourable conditions, a height of 2 ft. or more in the first season and 4 ft. or more in the second season being attainable with regular weeding and watering. A long taproot is developed early; this may attain a length of over 1 ft. within two months of germination. Weeds greatly hinder the growth of the seedling, which responds in a marked degree to weeding. The young plant grows best

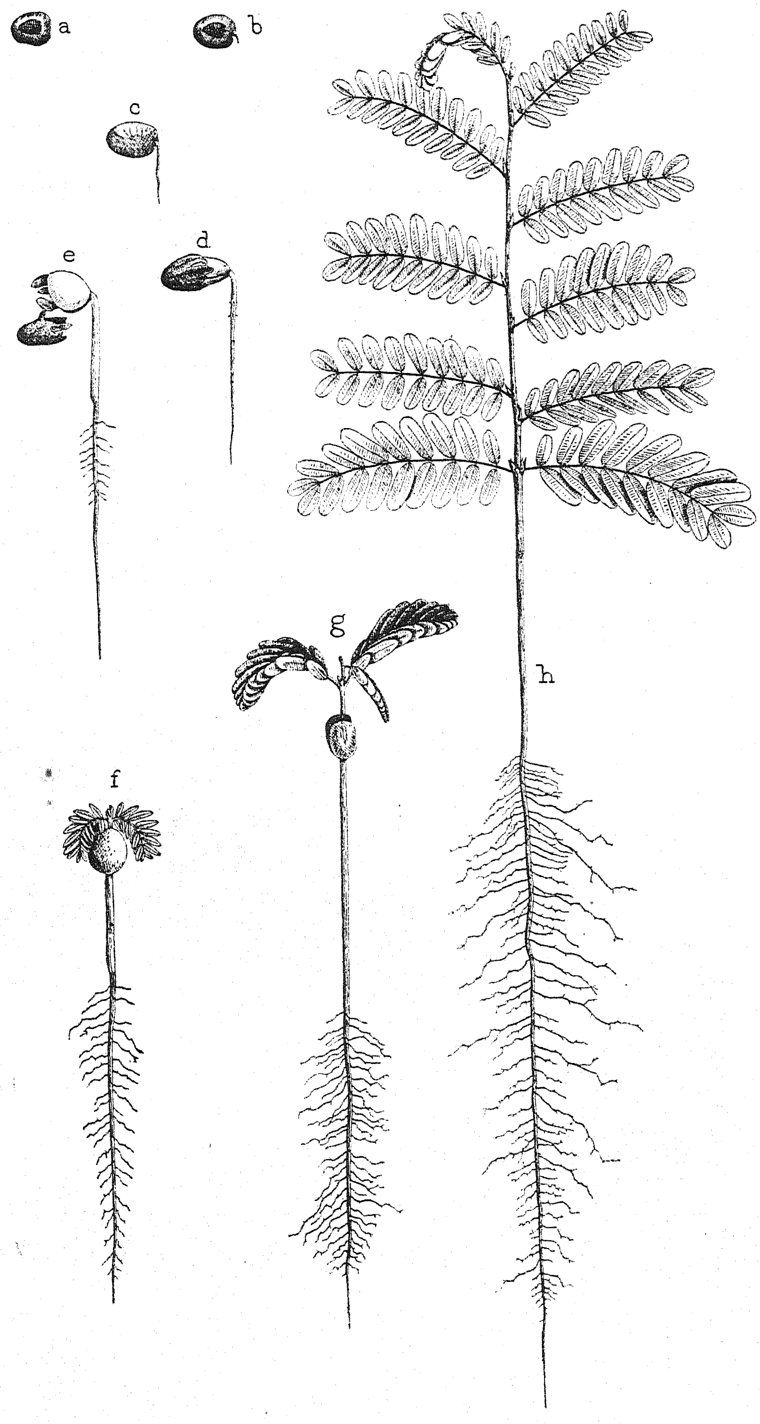

FIG. 143. *Tamarindus indica.* Seedling × $\frac{3}{8}$.
a, seed ; *b–e*, germination stages ; *f–h*, development of seedling to end of first season.

in a porous soil and if sheltered from the sun in the earlier stages ; it is very sensitive to frost.

Silvicultural characters. The tree is not exacting as regards soil, though it thrives best on deep alluvium : Haines says it has become naturalized among granite rocks near Kuru, Chota Nagpur. It is sensitive to frost, but withstands drought, having remained unaffected in the severe drought of 1899–1900 in the Deccan. The tree produces root-suckers. Owing to the fact that under its shade the ground is usually bare it is one of the most suitable trees for planting along fire-lines, for which purpose it has been employed in Mysore.[1] Its growth is somewhat slow.

Artificial reproduction. The tree is not difficult to propagate, whether by direct sowing along ploughed or hoed lines or by transplanting : in either case regular weeding and loosening of the soil stimulate growth. The seed should be sown about April in raised nursery beds composed of light porous soil, the beds being kept regularly watered and weeded : germination ordinarily commences in about five to ten days. Experiments at Dehra Dun showed that transplanting can be most successfully carried out during the first rains before the taproot reaches too great a length. Transplanting with entire root and stem in the second rains is more difficult and is liable to failure unless watering can be carried out for some time after. A fair amount of success has been attained at Dehra Dun by transplanting during the second rains after pruning the stem and taproot down to a length of about 2 in. and 9 in. respectively. Successful planting along fire-lines in Mysore has been carried out by raising seedlings in tile pots and planting them out 9 ft. by 9 ft. in pits 3 ft. cube, no subsequent watering or attention being required except to hoe up the soil round the plants once a year.

8. CASSIA, Linn.

Species 1. *C. Fistula*, Linn. ; 2. *C. renigera*, Wall. ; 3. *C. siamea*, Lam. ; 4. *C. auriculata*, Linn.

1. **Cassia Fistula,** Linn. Indian laburnum. Vern. *Amaltas*, Hind. ; *Bahawa*, Mar. ; *Kakke*, Kan. ; *Konnai*, Tam. ; *Rela*, Tel. ; *Sonaru*, Assam ; *Ngu*, Burm. (Fig. 144.)

A moderate-sized deciduous tree with a rather open crown ; leaves paripinnate with four to eight leaflets 2–6 in. long. Bark about 0·25 in. thick, in younger trees smooth, light grey, reddish brown inside, in older trees reddish brown, exfoliating in hard scales. This is one of the most beautiful of Indian flowering trees. Wood hard and durable, in demand for house-posts, carts, and agricultural implements. The pulp of the pods is a strong purgative (the Cassia Pulpa of the British Pharmacopoeia), while the bark is much in demand for tanning.

Distribution and habitat. Common in deciduous forests throughout the greater part of India and Burma, ascending to 4,000 ft. in the Himalaya ; also in Ceylon. The tree is not gregarious, but is scattered in mixed deciduous forests, often of a somewhat open type : it occurs fairly frequently in sal forest. Sometimes it approaches gregariousness in localities frequented by monkeys

[1] Ind. Forester, ix (1883), p. 143.

FIG. 144. *Cassia Fistula* in fruit, Dehra Dun, United Provinces.

(see under 'natural reproduction', p. 368). It is found on a variety of geological formations and will grow on poor shallow soil, as on the dry outer slopes of the Himalaya. In climatic requirements it shows a wide range. In its natural habitat the absolute maximum shade temperature varies from 100° to 120° F., the absolute minimum from 25° to 65° F., and the normal rainfall from 20 to 120 in. or more.

LEAF-SHEDDING, FLOWERING, AND FRUITING. The tree is leafless for a very short time, or hardly at all, between March and May, the new leaves appearing in April–May; these are bright green or sometimes a beautiful rich copper colour. The long pendulous racemes of large bright yellow flowers appear chiefly with the new leaves from April to June, but it is no uncommon thing to find the tree in flower even as late as September, particularly in dry years. The long cylindrical pods develop rapidly, reaching almost full length but not full thickness by October, when they are still soft and green. By November they are full-sized but still green and unripe; they commence ripening in December and continue ripening from January till March or April. The ripe pods are 1–2 ft. long or sometimes more, 0·75–1 in. in diameter, pendulous, cylindrical, dark brown, smooth, hard, indehiscent, septate into numerous one-seeded cells, the seeds being embedded in a dark brown sweetish pulp which is a strong purgative. The ripe pods hang for some time on the tree, commencing to fall about April–May, and continuing to fall in the following months: old pods may often be found on the trees in September or later along with the new half-grown green pods.

The seeds (Fig. 145, *a*) are 0·3–0·4 in. by 0·2–0·3 in., ovate, compressed, light brown, hard, smooth, shiny, with a moderately hard testa and a horny albumen. About 2,500 weigh 1 lb. Like many other hard leguminous seeds, those of *Cassia Fistula* take some time to germinate, some lying a whole year in the ground before doing so, even if regularly watered. Boiling the seeds for about five minutes before sowing has been found to give very good results in stimulating germination.[1] Tests carried out at Dehra Dun showed that the seeds retain their vitality unimpaired for at least two years. It was found that seed from pods one year old germinated more quickly than that from fresh pods, though the percentage of sound seeds in the former may be low owing to insect attacks. As regards the identity of the insects which do much damage by attacking the seeds within the pods, specimens of infected pods collected in the Siwaliks in December 1910 were kept under observation; from these were bred out (1) from May 4 to June 5, 1911, moths identified as *Trachylepidia fructicassiella*, Rag., and (2) from May 4 to 13, 1911, beetles identified as *Caryoborus gonagra*, Fabr.[2]

GERMINATION (Fig. 145, *b–e*). Epigeous. The radicle issues and the hypocotyl arches slightly, raising above ground the cotyledons enclosed in the testa, which soon falls, along with the albumen, when the cotyledons expand.

THE SEEDLING (Fig. 145).

Roots: primary root long, terete, tapering, wiry, yellow turning brown, glabrous: lateral roots numerous, fibrous, distributed down main root:

[1] Forest Report of Bihar and Orissa, 1917–18.

[2] Lefroy, Indian Insect Life, pp. 351 and 509. See also Ind. Mus. Notes, iv. 106, for damage by the tortricid moth *Cryptophebia carpophaga*, Wlsm.

nodules present. *Hypocotyl* distinct from root, 1–2·3 in. long, terete, tapering upwards, tender and green at first, becoming brown and wiry, minutely pubescent. *Cotyledons* sessile or very shortly petiolate, thin, plano-convex, somewhat fleshy, 0·7–0·8 in. by 0·4–0·5 in., elliptical oblong, apex rounded, base obtuse, entire, green, glabrous, 5-veined from the base, the three central veins more distinct than the lateral two. *Stem* erect, terete, wiry, pubescent; internodes 0·2–0·5 in. long in young stages. *Leaves* alternate or first pair opposite or sub-opposite, compound, paripinnate, earlier leaves with two pairs of leaflets, followed by leaves with three, then four pairs. Stipules minute, linear. Rachis 0·3–1·5 in. long in first season, pubescent. Leaflets opposite, very shortly petiolate, 0·5–1·7 in. by 0·2–0·5 in. in first season, unequally ovate lanceolate, acute, entire, pubescent, venation reticulate. Early leaves small, successive leaves becoming larger.

The effect of weeding and watering on the development of the seedling is most marked. Various plots of seedlings, some weeded and watered and others left unweeded and unwatered under purely natural conditions, were kept under observation at Dehra Dun, and the following measurements of the plants were recorded:

Cassia Fistula: measurements of seedlings.

Treatment.	Height at end of season.			
	1st.	2nd.	3rd.	4th.
Plants regularly weeded and watered	0 ft. 6 in.– 2 ft. 0 in.	2 ft. 0 in.– 12 ft. 10 in.	Maximum 15 ft.	—
Plants not weeded or watered	Maximum 0 ft. 9 in.	Maximum 1 ft. 10 in.	9 in.– 2ft. 8 in.	5 ft.–8 ft.

This indicates that under natural conditions the seedling develops slowly for the first few years, after which more rapid growth takes place. A fairly long taproot is produced at an early stage.

Seedlings are somewhat frost-tender, but have good power of recovery. If exposed to the sun during germination they are sensitive to drought, and the protection afforded by a covering of earth or a moderate growth of grass is useful; during the rains, however, much mortality occurs owing to the damping off of the seedlings where there is a heavy growth of weeds. In northern India the old leaves of natural seedlings drop about February, and new growth commences in March or early April.

Silvicultural characters. *Cassia Fistula* stands a moderate amount of shade. It is not frost-hardy, and suffered severely in the great frost of 1905 in northern India. In the abnormal drought of 1907 and 1908, which seriously affected the forests of Oudh, it proved to be decidedly hardy. It is not readily browsed, even by goats. It coppices vigorously and produces root-suckers freely from a root-system which is partly superficial. As already stated, it is not exacting as regards soil, and may be found on poor shallow soils.

Natural reproduction. As the natural reproduction of this tree was something of a mystery, I made a special study of it in 1910 and following years, with interesting results, for it appears to furnish an instance where animal assistance is necessary in obtaining natural reproduction, and so far no case has yet been observed of reproduction having been effected without the agency of animals.

FIG. 145. *Cassia Fistula*—SEEDLING × $\frac{3}{4}$

a—Seed b - e—Germination stages f - h—Development of seedling during first season

As already mentioned, the pods ripen from December–January onwards, hanging on the tree often for many months: they commence falling about April–May, continuing to fall until September or even later. After falling they lie on the ground, where they may be found in quantity during the succeeding cold and hot seasons. If pods are collected from the ground during these seasons and broken open each seed will be found loose in its own cell, the pulp having dried up: many of the seeds will as a rule be found to be eaten by grubs, while those which are not attacked will be quite sound, and in fact tests have shown that they retain their vitality for at least two years. Later in the season, and throughout the rains, pods lying untouched on the ground continue in much the same state, their hard outer shells often becoming partially eaten by white ants, but no sign of the germination of the seed being apparent.

In order to determine if possible what happens to the pods on the ground and how reproduction is effected, ripe pods were collected in March 1911 and laid on the ground on a marked plot at Dehra Dun with the view of periodical observations being made. Within a week the plot was discovered by jackals, which broke the pods up with their teeth in order to eat the pulp, scattering the seeds about the plot. This plot was left in the condition in which it was, with the remnants of the pods and seeds lying about as the jackals had left them. A second plot, however, was laid out alongside the original one, and in it another lot of ripe pods was laid on the ground; this plot, however, was covered with a strong cage of wire netting to keep animals off, and both plots were subsequently kept under observation, with the following results:

A. *Unprotected plot* (seeds scattered by jackals). (1) First season, germination commenced in July, after heavy rain, and continued throughout August; 24 seedlings came up, of which 15 damped off during the rains owing to heavy weed-growth, leaving 9 at the end of the season with a maximum height of 8 in. (2) Second season, 10 new seedlings appeared in July from seed which had lain dormant for a year; of these new seedlings 6, and of the old ones 2, damped off during the rains owing to heavy weed-growth, leaving at the end of the season 11 survivors up to 1 ft. 6 in. in height, of which 7 were old and 4 new seedlings. (3) Third season, the 11 survivors of last year remained alive and in good condition, attaining a maximum height of 2 ft. 8 in. by the end of the season; more dormant seeds germinated in July, but only 2 seedlings escaped damping off under a growth of weeds, and the total number of seedlings in the plot at the end of the season was 13.

B. *Protected plot* (covered with cage of wire netting to keep off animals). During the first rains the pulp within the pods became mouldy and rotten, but the seeds not attacked by grubs remained quite sound and fertile; many, however, were destroyed by grubs. The pods were kept under observation for four seasons. The seeds never escaped from them, and no germination took place. The shells of the pods became partly eaten by white ants, and the seeds were also to some extent attacked, though some remained sound until the end of the period of observation. The fact remained that no germination took place from the pods in this plot.

In addition to the observations just recorded many others have been

made in the forest with the view of ascertaining the extent to which animals assist in the natural reproduction of this tree, and no case has yet been met with in which the seed was found to germinate without having been extracted from the pods by animal agency; on the other hand, the remnants of pods broken up by animals have frequently been met with, and in many cases young seedlings have been found during the rains in the neighbourhood of these remnants. The animals which are known to eat the pulp of the pods, and are therefore useful agents in the spread of the tree, are monkeys, jackals, bears, and pigs; there are possibly other animals also. Although many of the seeds are scattered near the trees where the pods are eaten, without being swallowed by the animals, some are swallowed, as the seeds have been noticed in their excreta; in this way not only are the seeds disseminated, but germination is probably accelerated, an important point in the case of hard leguminous seeds of this kind. Some curious instances of natural reproduction traceable to the presence of animals have been observed. In certain localities along the base of the outer Himalaya the tree is so plentiful as to approach gregariousness, and although reproduction is partly from suckers, yet seedlings of various ages are also met with; such places have always been noticed to be frequented by numbers of monkeys, and there can be little doubt that they are the agents directly responsible for the spread of the tree.

As regards the time taken by the seeds to germinate under natural conditions, the observations already recorded have been confirmed by other observations in similar plots in which the seed has been extracted from the pods and scattered on the surface of the ground, namely, that the seed germinates chiefly during the rainy season after thorough soaking; only a portion of it may germinate during the first year, some lying dormant until the second or even the third year before germinating. In the case of seed lying on the surface of the ground much mortality is caused during germination by the destruction of the radicle by birds and insects, or through drying up in places exposed to the sun. Where the seed is buried by rain or otherwise, which frequently occurs under natural conditions, germination is more successful. A growth of grass, if not too rank, also protects the germinating seed. High mortality among the seedlings is caused subsequently by damping off where weed-growth is heavy.

Much of the natural reproduction met with in the forest consists of root-suckers; this is particularly the case on hill-sides, in cuttings, and other places where the surface roots are liable to be exposed.

To summarize, the following facts have been established regarding the natural reproduction of this tree from seed:

1. Reproduction is effected mainly, and perhaps entirely, through the agency of animals (monkeys, jackals, bears, pigs, and possibly others), which break open the pods to eat the pulp and thus scatter the seeds or swallow and disseminate them.

2. The seed germinates during the rainy season, some lying dormant until the second or even the third rains.

3. Germination is favoured if the seed becomes buried, and to some extent if it is protected by a moderate growth of grass; if the seed lies on the surface of the ground much mortality takes place during germination

owing to the destruction of the radicle by birds and insects, or to its drying up if exposed to the sun.

4. Many seedlings perish in heavy weed-growth owing to damping off during the rains.

ARTIFICIAL REPRODUCTION. The seed germinates tardily, that kept for a year germinating more readily than fresh seed. Certain methods of hastening the germination of hard leguminous seeds have been suggested in the introduction to this order, and these may prove effective. The seed should be sown in seed-beds in drills about 10 in. apart in March or April, and regularly watered; germination ordinarily takes place early in the rains, though some of the seed may lie dormant until the second year, germinating at different times from March onwards. Transplanting requires some care, but it can be carried out satisfactorily while the plants are still comparatively small during the first rains: basket planting is the most satisfactory method, the seedlings being transferred to the baskets in the first rains and planted out in the second rains. It is doubtful if direct sowings can be relied on for forest purposes unless this species is mixed with other species, owing to its uncertain germination: nevertheless, plants which do come up from direct sowings and are kept regularly weeded have been found to develop better than transplants.

SILVICULTURAL TREATMENT. The only satisfactory treatment for this species appears to be coppice, since natural reproduction by seed cannot be depended on over definite areas; the tree is not of sufficient value to raise in regular plantations except as an accessory species in mixture with other trees.

RATE OF GROWTH. The following records of periodical girth measurements in sample plots in the United Provinces show that the growth of trees (as distinct from coppice-shoots) is moderate only:

Cassia Fistula: rate of growth in high forest sample plots, United Provinces.

Number of sample plots.	Forest division.	Number of years under observation.	Number of trees under observation.	Girth class.	Mean annual girth increment for period.
				ft.	in.
2	Siwalik	7 and 12	7	1–2	0·16
			1	2–3	0·63
3	Lansdowne	12 and 17	3	$1\frac{1}{2}$–3	0·54

These plots were laid out primarily for the measurement of sal, and it is probable that the *Cassia* trees were dominated or even suppressed, so that the rate of growth exhibited here is probably slower than would be obtained under more favourable conditions.

Gamble's specimens gave about 9 rings per inch of radius, equivalent to a mean annual girth increment of 0·7 in. A cross-section 2 ft. 8 in. in girth in the silvicultural museum at Dehra Dun had 55 rings; this represents a mean annual girth increment of 0·58 in.

The rate of growth of coppice-shoots is fairly rapid while it lasts, but in a small-sized tree of this kind the growth slows down early. Measurements of coppice-shoots one year old in Bhandara, Central Provinces, in 1912–13, showed an average height of 6 ft. 1 in. as against 7 ft. 1 in. for teak. Measurements recorded by Mr. A. F. Broun in 1886 in a coppice coupe nine years old

at Bullawala, Dehra Dun, showed a mean girth of 7·7 in. and a mean height of 11 ft. 8 in. for *Cassia* as compared with 8·6 in. and 16 ft. respectively for sal.

The following figures give the results of measurements made in coppice coupes by Mr. C. M. McCrie in 1910 in Gorakhpur, United Provinces, together with measurements of sal coppice in the same coupes :

Cassia Fistula : rate of growth of coppice, Gorakhpur.

	Mean height.		Mean girth.	
Age.	*Cassia.*	Sal.	*Cassia.*	Sal.
years.	ft.	ft.	in.	in.
2	4·0	3·0	—	—
4	7·6	7·0	2·2	2·0
6	11·0	10·3	3·3	2·9
8	14·0	13·0	4·2	3·8
10	16·4	15·3	5·1	4·8
12	18·5	17·5	5·9	5·8
14	20·3	19·2	6·7	6·7
16	22·1	20·9	7·3	7·5

Measurements made in 1911 in coppice coupes two years old in Gonda, United Provinces, gave the following results :

	Cassia.	Sal.
Mean height	9 ft.	9 ft.
Average number of shoots per stool	1·5	1·7

2. **Cassia renigera,** Wall. Vern. *Ngushwe, ngusat,* Burm.

A small deciduous tree of the dry zone of Upper Burma, chiefly in dry open scrub forests. It is often cultivated for ornament, and grows and flowers well even in moist climates like that of Rangoon, although in its natural habitat it is accustomed to a dry climate and is capable of growing on comparatively poor soils. The tree has large pink flowers (Prain notes that the Shan hills specimens have yellow flowers) ; these appear in April and May in short racemes along the bare branches together with the young leaves, and the trees at this time are strikingly handsome. The pods are about 15–18 in. long, cylindrical and pendulous, resembling those of *C. Fistula.* The tree is leafless for some time in the hot season.

3. **Cassia siamea,** Lam. Syn. *C. florida,* Vahl. Vern. *Mezali,* Burm.

A moderate-sized evergreen tree with a dense crown, probably indigenous in Burma and the southernmost part of Madras ; largely planted for ornament. The yellow flowers, in large pyramidal terminal panicles, appear mainly in the hot season, but the flowering period is comparatively long, and flowers may often be found at various seasons. The pods are 4–10 in. long, and ripen towards the end of the hot season ; they hang in clusters and give the tree a somewhat untidy appearance. The tree grows fairly rapidly and is easy to cultivate ; it grows well on moist soils provided the drainage is good.

4. **Cassia auriculata,** Linn. Tanners' cassia. Vern. *Tarwar, tarwad, taroda,* Mar. ; *Avaram,* Tam. ; *Tangedu,* Tel. ; *Peikthingat,* Burm.

An evergreen often gregarious shrub ; leaves paripinnate with eight to twelve pairs of leaflets. It yields the most important tan-bark in India, and on this account is worth cultivation on a larger scale than at present. It is also a useful plant for clothing dry bare rocky ground and poor soil. In Madras it is sown as a green manure crop.

Distribution and habitat. Common in the drier parts of the Indian Peninsula from Ajmer and the Jumna river southwards, covering large areas in the Deccan; also found in the dry zone of Upper Burma. It is common on dry stony hills in open places and in scrub forest; it occurs also on black cotton soil and on laterite near the sea-coast. It is naturally a species of hot dry regions, where the absolute maximum shade temperature varies from 100° to nearly 120° F., the absolute minimum from 33° to 55° F., and the normal rainfall from 20 to 50 in.

Flowering and fruiting. The yellow flowers appear at various seasons, chiefly from October to May. The flowering and fruiting seasons overlap, and ripe fruit may be found for a considerable period of the year. The pod is flat, 3–4 in. long by about 0·6 in. broad. The seeds (Fig. 146, *a*) are 0·3 in. long; about 1,100 weigh 1 oz. Good seeds have no difficulty in germinating, and the percentage of fertility is fairly high. The plant begins to flower and fruit at an early age, usually when about a year old.

Germination (Fig. 146, *b–d*). Epigeous. The radicle emerges and descends; the hypocotyl elongates, raising above ground the cotyledons usually enclosed in the testa, which falls to the ground with the expansion of the cotyledons.

The seedling (Fig. 146).

Roots: primary root very long, terete, tapering, woody: lateral roots moderate in number, short to moderately long, distributed down main root. *Hypocotyl* distinct from root, 1–2 in. long, terete, tapering upwards, minutely pubescent when young. *Cotyledons* very shortly petiolate, foliaceous, somewhat fleshy, 0·6–0·8 in. by 0·5–0·7 in., sub-orbicular or broadly obovate, entire, green, glabrous. *Stem* erect, woody, glabrous, young parts green. *Leaves* alternate, compound, paripinnate, first 2–6 usually with 2 pairs of leaflets, subsequent leaves with 3–6 pairs or more. Stipules in young seedlings up to 0·25 in. long, linear or triangular acuminate, auriculate, green, pubescent. Rachis channelled above, sparsely pubescent. Leaflets shortly petioluled, with a filiform reddish gland at the base of each pair, 0·3–1 in. by 0·2–0·5 in., elliptical oblong, obtuse, mucronate, entire, terminal pair larger than remaining leaflets.

Silvicultural characters. This shrub does not stand shade or drip from overhead trees, and grows best in open places with an abundance of light. It is sensitive to frost, but stands drought well, growing readily on dry shallow soil. It prefers light porous soil; on water-logged ground or in soil containing an excess of moisture seedlings are apt to rot. The plant is avoided by goats and cattle, but plants cultivated near Dehra Dun were browsed by deer. It coppices well.

Cultivation. The plant has been frequently cultivated in various parts of India, and for the production of tan-bark it is worked as coppice. For tanning cow and buffalo hides the bark from shoots three to five years old gives the best results, whereas for tanning goat and sheep skins that of young shoots two years old is preferred: this refers to unirrigated plants. The rotation has thus to be fixed according to requirements.

For the formation of plantations stiff, water-logged, or alkaline soil and frosty localities should be avoided, care being taken to select places with soil which is light, porous, and not too moist. The site for the plantation should

FIG. 146. *Cassia auriculata.* Seedling $\times \frac{7}{8}$.
a, seed ; *b–d*, germination stages ; *e–g*, early development of seedling.

be an open one, trees and bushes being removed if they are present. Direct sowing has given much better results than transplanting, and it has been found advantageous to plough up the land before sowing. The sowing may be done either broadcast or in lines : the latter method is considered preferable as it facilitates weeding, thinning out the seedlings, and loosening the soil. Lines 3 to 4 ft. apart produce a dense crop. In southern India June has been found to be the best month for sowing, except where the monsoon rains are heavy, in which case October is preferable. The seedlings should be thinned out during the first season where necessary ; weeding and cultivation of the soil, though not always essential, stimulate growth. Irrigation is not necessary except in an arid climate like that of Sind, where irrigated sowings are said to have produced a height-growth of 20 ft. in two years. Nevertheless, irrigation is sometimes carried out during the first two years in the normal climatic region of the plant, and this hastens growth. With suitable tending, but without irrigation, the plants should reach a height of about 4 or 5 ft. in the second year, or under favourable conditions more.

9. BAUHINIA, Linn.

This genus contains over thirty Indian species, of which the majority are climbers, more than a third being trees and shrubs. They are easily recognized from the two leaflets being united for a portion of their length, forming a bilobed palmately veined leaf. Although none of the trees are of great importance as producers of timber, the bauhinias are of special interest as being widely represented throughout the forests of India and being characteristic members of many different forest types. Some are useful indirectly, for example *B. purpurea* for stocking frosty blanks, *B. racemosa* for afforesting open places, *B. retusa* for clothing hill slopes.

Among the better known species five are described below in some detail, and these contain certain characters in common. They require care in transplanting, the roots being somewhat sensitive. The fruit forms rapidly and ripens soon after flowering, except in *B. racemosa*, which takes several months to ripen its pods. The pods dehisce as a rule on the tree, scattering the seeds : this is particularly marked in the climber *B. Vahlii*, whose hard woody pods open with a crack in sunny weather and shoot the seeds to some distance. *B. malabarica* is an exception to the rule, the pods usually reaching the ground before dehiscing. The seed germinates readily, but in certain species (e. g. *B. malabarica* and *B. racemosa*) some of the seed may lie dormant for a year before germinating. It is of great advantage to successful reproduction if the seed becomes covered before germination, since the radicles of seeds germinating on the surface of the ground are liable to be eaten by birds or insects or to dry up before gaining a footing in the soil. Germination of the species studied is epigeous, but two species (*B. purpurea* and *B. variegata*) are interesting as showing a transition between hypogeous and epigeous germination.

The genus contains several climbers which are noxious to tree growth and require to be cut periodically in the forest. The best known is *B. Vahlii*, W. and A., a gigantic climber sometimes reaching a girth of 4 or 5 ft. or even more ; its eradication is difficult, since when cut down it at once sends out from the base new shoots which grow at a very rapid rate.

Species 1. *B. racemosa*, Lam.; 2. *B. malabarica*, Roxb.; 3. *B. retusa*, Ham.; 4. *B. purpurea*, Linn.; 5. *B. variegata*, Linn.

1. **Bauhinia racemosa,** Linn. Vern. *Jhinjeri, jhanjhora, makuna*, Hind.; *Apta*, Mar.; *Banne*, Kan.; *Vattátthi*, Tam.; *Ari*, Tel.; *Palan*, Burm.

A small to moderate-sized deciduous (or evergreen ?) tree with a somewhat crooked bole, drooping branchlets, and small leaves broader than long, cleft nearly half-way down. Bark bluish black, rough with numerous deep vertical cracks, pinkish red inside, turning brown on exposure. The tree is of no importance for timber, but the bast yields a strong cordage fibre. Silviculturally it is of some importance as a common constituent of the drier types of forest and as a useful species for filling blanks.

Distribution and habitat. Throughout the greater part of India in deciduous forests of a dry type, ascending to 5,000 ft. in the western Himalaya; frequent in grassy blanks and open spaces, and common also on dry hills. In Burma it occurs on savannah lands and is fairly common in the dry zone associated with *Acacia Catechu*, *A. leucophloea*, *Pentacme suavis*, *Shorea obtusa*, *Terminalia Oliveri*, *T. tomentosa*, *Bridelia retusa*, *Diospyros burmanica*, *Buchanania latifolia*, *Zizyphus Jujuba*, *Odina Wodier*, *Cassia renigera*, *Phyllanthus Emblica*, and other trees.

In its natural habitat the absolute maximum shade temperature varies from 100° to 118° F., the absolute minimum from 30° to 55° F., and the normal rainfall from 30 to 85 in.

Leaf-shedding, flowering, and fruiting. The old leaves are shed in the cold or early hot season and the new foliage appears in the hot season, sometimes before the old leaves have all fallen. The racemes of small creamy white flowers appear from March to June. The pods ripen in November–December and remain some months on the tree, falling towards the end of the hot season or early in the rains: they are indehiscent, 5–8 in. long, dark brown when ripe, thick, rigid, falcate, containing twelve to twenty seeds which rattle in the septate pods. The seeds (Fig. 147, *a*) are dark reddish brown, hard, smooth, shining, 0·3–0·4 in. by 0·18–0·25 in., with a hard fairly thick testa: about 220–250 weigh 1 oz. The seeds have a fairly high germinative power (58 to 95 per cent. in tests at Dehra Dun) and retain their vitality to some extent for at least one year. In order to collect the seed the pods should be plucked off the trees when thoroughly ripe, from January to March; they should then be hammered open and the seeds separated out.

Germination (Fig. 147, *b–e*). Epigeous. The radicle emerges from one end of the seed and descends; the hypocotyl elongates by arching, and the cotyledons, enclosed in the testa, are carried up above ground, the testa falling with their expansion.

The seedling (Fig. 147).

Roots: primary root moderately long, wiry, flexuose: lateral roots moderate in number, fibrous: nodules present. *Hypocotyl* distinct from and thicker than root, 0·3–0·5 in. long, slightly compressed and more or less grooved down two sides, tapering downwards, green, glabrous. *Cotyledons* sub-sessile or very shortly petiolate, 0·9–1·2 in. by 0·5–0·6 in., foliaceous, somewhat fleshy, obliquely ovate elliptical, entire, green, glabrous. *Stem* erect, terete or slightly compressed, wiry, zigzag at the nodes, green, young parts minutely pubescent, soon becoming glabrous. *Leaves* simple, alternate.

FIG. 147. *Bauhinia racemosa*. Seedling × $\frac{3}{4}$.
a, seed ; *b–e*, germination stages ; *f–h*, early development of seedling.

Stipules minute, subulate. Petiole 0·4–1 in. long. Lamina 0·6–1·5 in. by 1–2 in., broader than long, cleft nearly half-way down, mucronate, entire, sub-coriaceous, glaucous beneath, darker above, glabrous, apices of lobes rounded, each lobe palmately 7- or 9-veined, with a straight midrib between the lobes.

The development of the seedling is rapid under favourable conditions, that is, particularly if weeding and watering are carried out. The young plant is of straggling habit, commencing to form strong side branches from the base at an early age; these side branches succeed each other in alternate succession up the stem and grow rapidly, those near the base attaining a length of over 3 ft. by the end of the first season in the case of vigorous plants. The stem and branches droop, their extremities often touching the ground. A long taproot is developed at an early age, and may attain a length of over 2 ft. in three months from germination. Growth ceases in November–December, and new growth commences in March; in the second season the growth usually starts with the elongation of the lower side branches, the main stem showing little or no growth until May or later (Dehra Dun). The leaves commence to fall in December and continue falling till May.

Seedlings have good power of pushing their way through grass and low weeds, but their development suffers until the weeds are overtopped; regular weeding has a marked effect on their growth. Drought is to be feared chiefly in the germinating stages in the case of seed lying on hard bare ground exposed to the sun. In frosty localities the seedlings are sometimes killed back, especially in grass, but have good power of recovery.

The following measurements of seedlings in experimental plots at Dehra Dun will give some idea of the rate of growth under different conditions:

Bauhinia racemosa: rate of growth of seedlings, Dehra Dun.

Condition under which grown.	Height and other particulars at end of season. 1st season.	2nd season.	3rd season.	4th season.
Weeded irrigated sowings	Maximum 4 ft. 2 in. (side branches up to 3 ft. 3 in. long)	Maximum 9 ft. 0 in. (dense crop, very vigorous)	Maximum 15 ft. 0 in. (maximum diameter 2½ in. at 2½ ft. from the ground)	
Unweeded irrigated sowings	Maximum 2 ft. 0 in.	Maximum 3 ft. 6 in. (chiefly under 1 ft. 6 in. among weeds)	0 ft. 2½ in.–3 ft. 9 in. (chiefly under 1 ft. 8 in.)	
Weeded unirrigated sowings	Maximum 3 ft. 0 in.	Maximum 3 ft. 2 in.	Maximum 7 ft. 7 in.	
Unweeded unirrigated sowings (i. e. natural conditions)	(1) Maximum 2 ft. 7 in.	Maximum 3 ft. 6 in.	0 ft. 5 in.–4 ft. 8 in. (chiefly under 2 ft. except where weeds scanty)	
	(2) Maximum 0 ft. 6½ in.	Maximum 1 ft. 3 in.	0 ft. 4½ in.–3 ft. 0 in.	Maximum 7 ft. 0 in.
Nursery-raised plants, transplanted with entire roots and stem	Maximum 1 ft. 2 in.	Maximum 3 ft. 6 in.	2 ft. 9 in.–4 ft. 2 in.	
Nursery-raised plants, transplanted with pruned roots and stem	Maximum 0 ft. 9 in.	Maximum 1 ft. 9 in.	0 ft. 10 in.–3 ft. 8 in.	
Weeded unirrigated line sowings with field crops	(1) Maximum 1 ft. 9 in.	Maximum 2 ft. 4 in.		
	(2) —	3 in.–3 ft. 10 in.		

These figures demonstrate the great value of weeding, whether irrigation be carried out or not.

Silvicultural characters. The tree is a light-demander, though sometimes found in slight shade. It is affected to some extent by frost, but has good power of recovery. In the abnormal drought of 1907 and 1908 in the forests of Oudh it proved to be decidedly hardy. The tree produces root-suckers and coppices well.

Natural reproduction. The pods fall towards the end of the hot season or early in the rains. If the seed be extracted from the pods germination commences with the early showers of May and continues for some time during the rains, some seed lying even until the second rains before it germinates. The pods being indehiscent the seeds do not escape for some time after the pods fall; this they do ordinarily through the pods rotting or becoming eaten by white ants, but in any case it is probable that under natural conditions most if not all of the seed fails to germinate until the rains of the following year. An important aid to successful germination is the covering of the seed by earth and débris, which often takes place under natural conditions during the period in which the seed lies on the ground before germinating. When germination takes place on the surface of the ground there is much mortality through the drying up of the radicle or its destruction by birds and insects. Natural seedlings are capable of struggling successfully through low weeds and grass, but their growth is kept back until the weeds are overtopped. In dry hot situations the seedlings tend to die back for a few years, finally starting upward growth when the root-system has established itself.

Artificial reproduction. Experiments at Dehra Dun have shown that the best results are obtained by direct sowings in lines, the young plants being kept weeded and the soil being loosened from time to time. Line sowings with field crops, the crop employed being the lesser millet or *mandwa* (*Eleusine coracana*), gave good results provided the lines were kept clear of crops to a width of 2 ft.

Transplanting can be carried out successfully with small nursery plants, the seed being sown in nursery drills not less than 9 in. apart in April or May and the seedlings transplanted during the first rains; the long taproot prevents successful transplanting later unless regular watering can be carried out, and experiments in pruning down the stem and taproot were only partially successful.

This is one of the species which have been raised by sowings in conjunction with field crops (sesamum, *tur* or *arhar*, and cotton) in the Amraoti forest division, Berar.[1]

Silvicultural treatment. The tree is only of secondary importance, and is treated as an accessory species. Where a regular system is applied to the mixed forests in which it occurs the treatment usually followed is that of coppice or coppice-with-standards.

Rate of growth. So far as available statistics show, the rate of growth in high forest is slow. Sample plot measurements in the Siwaliks, extending over a period of twelve years, showed the following mean annual girth increments for the period:

Trees 12–24 in. in girth—0·21 in. (four measurements).
Trees 24–36 in. in girth—0·33 in. (four measurements).

[1] Ind. Forester, xxxvii (1911), p. 8.

As regards coppice, the following figures resulting from measurements made in 1910 by Mr. C. M. McCrie in the Ramgarh coppice coupes, Gorakhpur, United Provinces, indicate that the rate of growth for a time is fairly fast:

Bauhinia racemosa: rate of growth of coppice, Gorakhpur.

Age.	Mean height.	Mean girth.
years.	ft.	in.
2	4·5	—
4	9·0	3·3
6	12·5	4·5
8	16·0	5·7
10	19·5	6·8
12	23·0	7·5

2. **Bauhinia malabarica,** Roxb. Vern. *Amli, imli, amlosa,* Hind.; *Karmai,* Beng.; *Shadlu,* Kan.; *Atthi,* Tam.; *Arám puli,* Mal.; *Bwechin,* Burm.

A moderate-sized tree, evergreen or nearly so, with a bushy crown of dark green foliage; leaves 2–3 in. long, broader than long, cleft about one-third of the length, acid to the taste, unlike those of *B. racemosa,* which they resemble somewhat otherwise. Bark rough, dark brown, exfoliating in long strips, pink to red inside. The wood is used only for fuel.

Distribution and habitat. Throughout the greater part of India and Burma, but not in the driest tracts, in deciduous forests usually of a moister type than those in which *B. racemosa* is found. It is a common accessory species in the sal forests of India, in the teak and lower mixed forests of Burma, and in the moist forests of western and southern India.

In its natural habitat the absolute maximum shade temperature varies from 95° to 110° F., the absolute minimum from 32° to 62° F., and the normal rainfall from 40 to 120 in. or more.

Flowering and fruiting. The dull whitish flowers, in small axillary racemes, appear from August to October, and the pods develop rapidly, ripening from January to March, and often hanging in large quantities on the trees. The pods are 7–12 in. long by about 0·75 in. broad, flat, flexible, many seeded, tapering gradually to a point. The pods either dehisce on the trees towards the end of the hot season or fall before dehiscing. The seeds (Fig. 148, *a*), of which about 320 weigh 1 oz., retain their vitality to some extent for one year.

Germination (Fig. 148, *b–e*). Epigeous. The radicle emerges and descends, and the hypocotyl elongates by arching; the cotyledons, enclosed in the testa, are raised above the ground, and the testa falls with their expansion.

The seedling (Fig. 148).

Roots: primary root moderately long, terete, tapering: lateral roots moderate in number and length, fibrous. *Hypocotyl* distinct from and thicker than the root, 0·3–0·8 in. long, terete or slightly compressed, fusiform or tapering slightly upwards, sparsely covered with minute stiff hairs. *Cotyledons*: petioles 0·06 in. long, flattened above; lamina 0·8–1·1 in. by 0·6–0·7 in., foliaceous, somewhat fleshy, oblong or elliptical, entire, sparsely covered with minute stiff hairs, 5-veined from the base. *Stem* erect, terete or slightly compressed, somewhat zigzag at the nodes, pubescent. *Leaves* simple, alternate, acid. Stipules 0·15 in. long, linear falcate, pubescent. Petiole 0·4–0·6 in. long, pubescent. Lamina 0·5–1 in. by 1–2 in., broader than long, cleft to

about one-third of the length, mucronate, base cordate, entire, glabrous, palmately 7-veined with a straight midrib between the lobes.

Under natural conditions the development of the seedling is slow, but if

FIG. 148. *Bauhinia malabarica.* Seedling × $\frac{3}{4}$.
a, seed ; *b–e*, germination stages ; *f–h*, development of seedling during first season.

weeded and watered it grows more rapidly. Seedlings grown under natural conditions in grass at Dehra Dun had maximum heights of 0 ft. 4 in., 1 ft. 8 in., and 5 ft. 7 in. at the end of the first, second, and third seasons respectively. The seedling has good power of struggling through grass and low weeds, but

its growth suffers in the process and increases rapidly when the weeds are overtopped. The leaves fall about December–February, and new growth starts in March (Dehra Dun). The seedling is somewhat frost-tender in early youth.

Natural reproduction. The seeds are sometimes scattered through the pods dehiscing on the tree in dry hot weather, but perhaps more commonly they escape either through the dehiscence of the pod after reaching the ground or through the pod valves becoming eaten by white ants or rotting off. Germination commences early in the rains and continues for a time during the rainy season; many seeds lie ungerminated until the second rainy season. Germination is most successful on loose soil where the seed becomes buried; if it takes place on the surface of the ground the radicle is apt to dry up or to become eaten by insects or birds before it can penetrate the soil.

Rate of growth. Little is known regarding the rate of growth of this species. Two trees measured for seven years in a sample plot in the Siwaliks showed the following growth:

1. Girth class 12 to 24 in.—mean annual girth increment for the period, 0·11 in.
2. Girth class 24 to 36 in.—mean annual girth increment for the period, 0·6 in.

3. **Bauhinia retusa,** Ham. Vern. *Kandla, semla, kurál,* Hind.; *Nirpa,* Tel.

A moderate-sized tree, never quite leafless, with entire or emarginate coriaceous leaves 4–6 in. broad, somewhat broader than long. Bark 0·3–0·5 in. thick, dark brown, longitudinally cracked, pale pink inside. The bast yields a fibre and the cortex a clear gum, for which the trees are extensively tapped in some localities. Gamble says the wood is the best of those of the bauhinias, but is not much used. Silviculturally the tree is important in the outer Himalaya, as it covers the hill-sides at elevations intermediate between those at which many of the low-level species disappear and *Quercus incana* and its associates commence.

Distribution and habitat. Sub-Himalayan tract and outer Himalaya from the Beas to Nepal, Chota Nagpur, Orissa, Central Provinces (Raipur, Bilaspur, South Chanda, Bhandara, Balaghat), and the Circars. In the outer Himalaya it is gregarious at elevations chiefly between 3,000 and 4,500 ft., but on southern slopes it occasionally ascends to 6,000 ft., as below Naini Tal, where it is associated with *Quercus incana* and *Pinus longifolia*; it is also found in the Siwalik hills. According to Parker it occurs in the Jowlian reserve, Khanpur range, Hazara, but has not been collected between this and the Beas. It is always found on well-drained ground, on hill slopes or the sides of ravines. In the Himalayan and sub-Himalayan region it occurs mainly on shale, sandstone, and conglomerate. In Chota Nagpur it is common on the hills, especially on northern slopes, in Singhbum and elsewhere. Haines says it is very common on quartzite along the Konar nadi, Hazaribagh, and that it is found on quartzite rocks near Deori, Bhandara, Central Provinces.

In its natural habitat the absolute maximum shade temperature varies from 95° to 115° F., the absolute minimum from 28° to 42° F., and the normal rainfall from 40 to 90 in.

LEAF-SHEDDING, FLOWERING, AND FRUITING. The tree is never leafless: the old leaves fall during the hot season and the new bright green foliage appears in May and June, at which time the trees are conspicuous. The flowers appear from September to November, and the trees are then covered with masses of yellowish white blossom. The pods form rapidly, becoming a rich crimson colour before ripening; the masses of crimson pods hanging amongst the rich green foliage give the trees a particularly handsome appearance from January onwards. The pods are 4–7 in. by 1·2–1·7 in., flat and hard; they dehisce on the tree in June (outer Himalaya), the valves curling spirally and scattering the seeds. The seeds are dark brown, smooth, flat, about 0·5 in. in diameter.

SILVICULTURAL CHARACTERS. The silviculture of this tree has not yet been studied in detail. One particular requirement is a demand for perfect drainage. Otherwise its demands do not appear to be exacting, as it can grow on poor stony ground where many species could not survive.

NATURAL REPRODUCTION. The seeds, scattered towards the end of the hot season, germinate early in the rains, and, as in the case of other bauhinias, the establishment of the seedling appears to depend largely on the seed becoming covered with earth and débris, while new soil formed by landslips and erosion is very favourable to germination, and germinating seeds are sometimes found in quantity on such ground during the rains. These conditions commonly obtain on the hilly ground frequented by the tree, the flat seed lending itself to being covered with the loose earth washed down in the rains; this may to some extent account for the gregariousness of the species in the outer Himalaya.

RATE OF GROWTH. Reliable statistics are wanting as regards the rate of growth of seedling trees. A cross-section 3 ft. 3 in. in girth in the silvicultural museum at Dehra Dun had 47 rings, giving a mean annual girth increment of 0·83 in.

Measurements made in 1916 in the Saitba coppice coupes, Kolhan, Chota Nagpur, show the following average rate of growth of coppice of *Bauhinia retusa* and sal respectively in a somewhat poor locality:

Bauhinia retusa: rate of growth of coppice, Saitba.

	Mean height.		Mean girth at 4½ ft. from ground.	
Age.	*Bauhinia retusa.*	Sal.	*Bauhinia retusa.*	Sal.
years.	ft.	ft.	in.	in.
2	5·5	9·0	2·5	4·0
4	11·0	16·0*	4·3	6·5
6	15·0	20·0	5·7	8·6
8	19·5	22·5	7·0	10·3
10	23·5	24·5	8·0	11·5
12	27·5	26·5	9·0	12·6
14	31·0	28·5	10·0	13·6

4. **Bauhinia purpurea,** Linn. Vern. *Khairwál, karár, koliár, kaniár,* Hind.; *Atmatti,* Mar.; *Sarúl, baswanapada, kanchiväla,* Kan.; *Kanchan,* Tel.; *Mahahlègani,* Burm.

A moderate-sized evergreen tree with a bushy crown; leaves 3–6 in. long, somewhat longer than broad, cleft about half-way down. Bark dark grey or

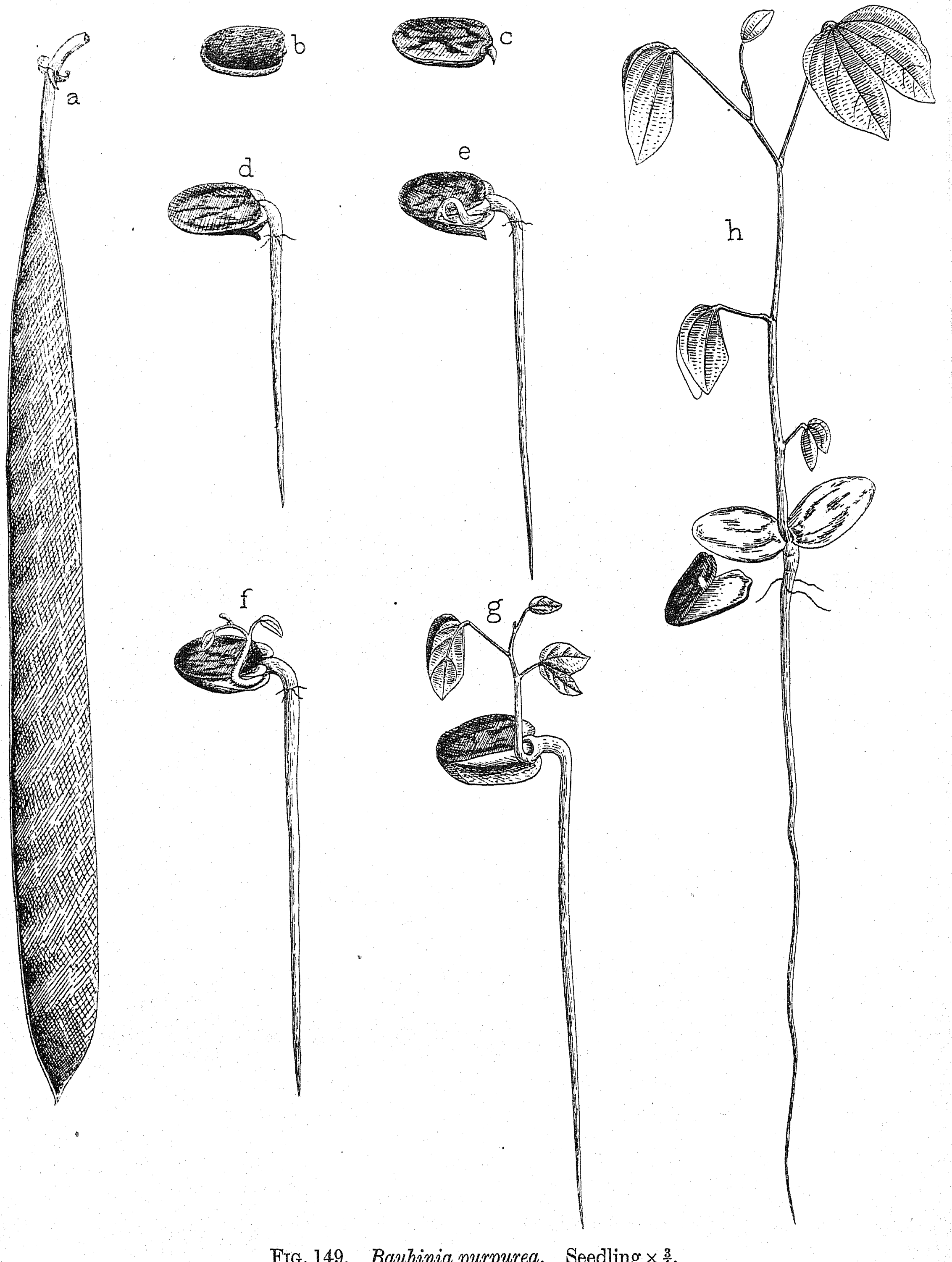

Fig. 149. *Bauhinia purpurea.* Seedling × $\frac{3}{4}$.
a, fruit ; *b*, seed ; *c–f*, germination stages ; *g–h*, development of seedling during first season.

brown, pink to pale yellow inside. The wood is used for agricultural implements and the bark for tanning.

DISTRIBUTION AND HABITAT. Common in the mixed and sal forests of the sub-Himalayan tract, ascending the outer hills and valleys to 4,000 ft., Assam and the Indian Peninsula; not indigenous in Burma. In its region the tree is characteristic of mixed deciduous forests, often of a dry type, occurring on hill slopes, in valleys, and along streams. Frequently cultivated for the sake of its handsome flowers. In its natural habitat the absolute maximum shade temperature varies from 100° to 115° F., the absolute minimum from 30° to 50° F., and the normal rainfall from 40 to 85 in.

FLOWERING AND FRUITING. The terminal panicled racemes of large purple, deep rose to lilac flowers appear amongst the foliage from September to December. The flowers are very fragrant, and are visited by numerous bees, by whose agency pollination is effected. The pods (Fig. 149, *a*) form rapidly, some attaining a fair length while the tree is still in flower: they ripen from January to March, and are then greenish purple, 6–12 in. by 0·7–1 in., flat, fairly thick, pointed, slightly falcate, with coriaceous valves, containing 10–15 seeds. The seeds (Fig. 149, *b*) are brown, compressed, 0·6 by 0·5 in. They germinate readily and have a high percentage of fertility, which they retain unimpaired for at least one year; tests at Dehra Dun with seed kept for 14 months showed a fertility of 100 per cent. The pods dehisce on the tree during the hot season, scattering the seeds.

GERMINATION (Fig. 149, *c–f*). Strictly speaking epigeous, but shows a transition between the hypogeous and epigeous form. The radicle emerges, while the plumule commences to grow and the young shoot to develop before emerging from between the cotyledons: the latter separate very slightly and the young shoot extricates itself by arching or bending as in hypogeous germination, but after its emergence the cotyledons, which become green, separate and are carried above ground on a short hypocotyl.

THE SEEDLING (Fig. 149).

Roots: primary root moderately long and thick, terete, tapering: lateral roots moderate in number, fibrous. *Hypocotyl* distinct from the root, 0·2–0·5 in. long, moderately thick, white or pale green, glabrous, subterranean or at ground-level. *Cotyledons* sub-sessile, 0·6–0·8 in. by 0·4–0·5 in., plano-convex, somewhat fleshy, oblong, apex rounded, base sagittate, green, glabrous. *Stem* erect, terete or slightly compressed, somewhat zigzag at the nodes, glabrous or young parts minutely pubescent; internodes 0·4–1·5 in. long. *Leaves* simple, alternate, at first small, becoming consecutively larger. Stipules 0·05 in. long, falcate. Petiole 0·3–1·3 in. long, finely pubescent. Lamina 0·3–1·5 in. by 0·3–1·5 in., about as broad as long, cleft to nearly half-way down, mucronate, apices of lobes acute, base cordate or truncate, entire, young leaves finely pubescent, palmately 7-veined with a straight midrib between the lobes.

The growth of the seedling is very rapid under favourable conditions. Nursery-raised plants at Dehra Dun, regularly weeded and watered, attained a maximum height of 3 ft. 9 in. in two months from germination. In one plot 17 nursery plants varied from 3 ft. 7 in. to 10 ft. 5 in. by the end of the first season; by the end of the second season they had a maximum height of 15 ft. 6 in., and were in flower. Under less favourable conditions the growth

is much slower. The season's growth ends about November, and new growth begins in February (Dehra Dun).

Silvicultural characters. The tree is a moderate light-demander. It is decidedly frost-hardy, as is proved by the fact that it may be found surviving on grass-lands subject to bad frosts, where all but the most frost-hardy trees fail.

Natural reproduction. The seeds germinate readily at the beginning of the rains, when numerous young seedlings may be found in the neighbourhood of seed-bearers. Where germination takes place on the surface of the ground, however, much mortality takes place owing to the drying up of the radicle if exposed to the sun. The survival of the seedlings is greatly facilitated if the seed becomes buried in loose earth before germination and the roots of the young plant are not exposed.

Artificial reproduction. Experiments at Dehra Dun have shown that the best results are attained by line sowings kept regularly weeded : irrigation also has a marked effect on the growth. The seedlings are somewhat sensitive to transplanting, which has to be done with care. The seed should be sown in the nursery in April or May in drills 9–10 in. apart, and covered to a depth of about a quarter of an inch, regular watering and weeding being carried out. The seedlings appear in about 4–10 days, and can be transplanted while still of small size during the first rains. Transplanting with unpruned stem and roots should not be attempted during the second rains unless regular watering is possible for some time. A certain amount of success has been attained by transplanting after pruning the stem and taproot down to 2 and 9 in. respectively, but this checks the growth severely for a time.

5. **Bauhinia variegata**, Linn. Vern. *Kachnár*, Hind. ; *Kanchan, thaur*, Mar.

A moderate-sized deciduous tree with leaves 3–6 in. long, as broad as or broader than long, cleft about one-quarter to one-third down. Bark grey, with longitudinal cracks, pale pink inside. The wood is used for agricultural implements and the bark for tanning. The tree is extremely handsome when in flower, and is largely planted for ornament.

Distribution and habitat. The sub-Himalayan tract and outer hills and valleys from the Indus eastward, ascending to 5,000 ft., Assam, Burma, Chota Nagpur, Central Provinces, and other parts of the Indian Peninsula. Frequently cultivated for ornament. It is essentially a tree of the mixed deciduous forests, often of a somewhat dry type, and occurs frequently on hilly ground. It ascends some distance into the Himalayan valleys, and occurs gregariously on some of the outer hills up to 5,000 ft. on southerly aspects. In the Indian Peninsula it occurs chiefly on hilly ground, and in Burma it affects the drier types of mixed forest, entering the dry zone and ascending the hills to over 3,000 ft. In its natural habitat the absolute maximum shade temperature varies from 97° to 115° F., the absolute minimum from 28° to 45° F., and the normal rainfall from 40 to 100 in.

Leaf-shedding, flowering, and fruiting. The leaves commence falling in November–December, and the tree is leafless or nearly so by March ; the new leaves appear in April and May. The large pink to purple or white flowers appear from February to April, chiefly on the upper leafless branches,

the lower branches often being still in leaf. The flowers are fragrant and are visited by bees, by whose agency pollination is effected. The pods (Fig. 150, *a*) form rapidly, ripening in May and June (northern India) : they are 6–12 in. by 0·7–1 in., hard and flat, with 10 to 15 seeds, and dehisce for the most part on the tree, scattering the seeds. The seeds (Fig. 150, *b*) are 0·5–0·75 in. by 0·5–0·7 in., nearly circular, flat, brown, with a somewhat coriaceous testa, 70–100 weighing 1 oz. ; they germinate readily and show a high percentage of fertility, which is retained to some extent for at least a year.

Germination (Fig. 150, *c–g*) as in *B. purpurea*.

The seedling (Fig. 150).

Roots : primary root moderately long and thick, terete, tapering, whitish or light brown : lateral roots moderate in number, fibrous. *Hypocotyl* distinct from the root, 0·1–0·15 in. long, thick, tapering downwards, minutely pubescent or glabrescent, subterranean or at ground-level. *Cotyledons* sessile or sub-sessile, 0·8–1 in. by 0·6–0·8 in., plano-convex, somewhat fleshy, broadly elliptical or sub-orbicular, usually oblique, apex rounded, base slightly auriculate or sub-sagittate, entire, yellow or greenish, glabrous. *Stem* often arched during germination, soon becoming erect, grooved and angular, pubescent ; internodes 0·3–1·5 in. long. *Leaves* simple, alternate, the first one or two often small and abortive. Stipules minute. Petiole 0·3–1 in. long, pubescent. Lamina 0·4–0·9 in. by 0·8–1·6 in., broader than long, cleft to about one-quarter to one-third of the length, mucronate, apices of lobes often acute, entire, sub-coriaceous, glabrous above, slightly pubescent beneath, palmately 7- or 9-veined with a straight midrib between the lobes.

If weeded and watered the seedling develops rapidly. Nursery-raised plants at Dehra Dun attained a height up to 3 ft. 4 in. in two months from germination, with taproots up to 1 ft. 7 in. long and 0·5 in. thick. Eight nursery-raised seedlings in one plot varied from 3 ft. 7 in. to 7 ft. 10 in. in height by the end of the first season. Under less favourable conditions the growth is considerably less, natural seedlings usually attaining a maximum height of 1 ft. by the end of the first season. The season's growth ceases about November, and new growth commences in February (Dehra Dun).

Natural reproduction. The seeds, which are scattered before the beginning of the monsoon, germinate readily when the rains begin, and germinating seeds may be found in quantity round the trees. But unless the seed happens to become buried in earth and débris, or is sheltered from the sun, most if not all of the young plants may die off owing to the drying up of the radicle if exposed to the sun, while birds and insects also cause a good deal of mortality by eating off the radicles. The most favourable condition for the establishment of reproduction appears to be the presence of loose porous well-drained soil, in which in the first place the seed has a chance of becoming covered with earth, and in the second place the seedling develops sufficiently rapidly to overcome weed-growth.

Artificial reproduction. The most successful means of raising the tree artificially is by sowing in lines in which the soil has been well loosened, followed by regular weeding and loosening of the soil. Unless regular watering can be carried out, transplanting is difficult except in the case of small plants during the first rains. The seed should be sown in May in drills 9–10 in. apart : the young plants usually appear in 4 to 10 days, and may be transplanted

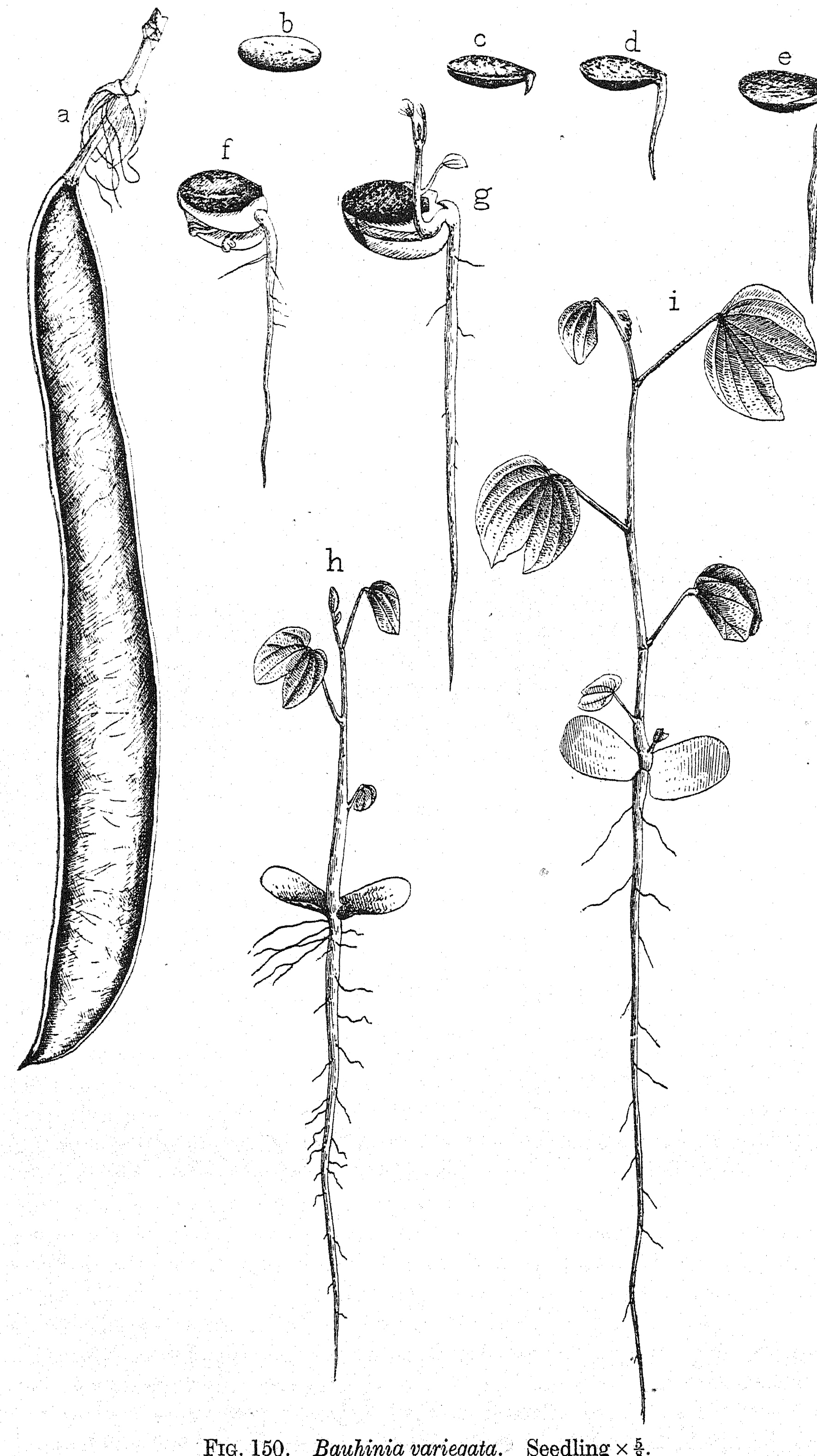

FIG. 150. *Bauhinia variegata.* Seedling $\times \frac{5}{8}$.
a, fruit ; *b*, seed ; *c–g*, germination stages ; *h*, *i*, development of seedling to end of first season.

while still comparatively small during the first rains. Trees planted for ornament may be kept a second year in the nursery, but regular watering is necessary in the dry season following transplanting; in this case either the seedlings should be pricked out in the nursery during the first rains or the drills should be at least 12 in. apart, and the seedlings should be thinned out where necessary.

Rate of growth. The only authentic statistics relate to coppice coupes at Ramgarh near Dehra Dun, the following measurements having been recorded by Mr. A. F. Broun in 1886 (sal coppice measurements in the same coupes entered for comparison):

Bauhinia variegata: coppice measurements, Ramgarh, Dehra Dun.

Age.	Mean height. *Bauhinia variegata.*	Sal.	Mean girth. *Bauhinia variegata.*	Sal.
years.	ft.	ft.	in.	in.
8	18	16·3	7·5	8·3
8	20	13·2	6·0	7·1
9	13	16·0	7·0	8·6
10	10	11·9	4·0	5·9

Sub-Order III. MIMOSEAE

Genera 1. Prosopis, Linn.; 2. Xylia, Benth.; 3. Acacia, Willd.; 4. Albizzia, Durazzini; 5. Dichrostachys, DC.; 6. Adenanthera, Linn.; 7. Pithecolobium, Martius; 8. Leucaena, Benth.

1. PROSOPIS, Linn.

Species 1. *P. spicigera*, Linn.; 2. *P. juliflora*, DC.

1. **Prosopis spicigera,** Linn. Vern. *Jand*, Punjab; *Kandi*, Sind; *Khejra*, Rajputana; *Semru, sumri*, Guz.; *Shema, saunder*, Mar.; *Banni*, Kan.; *Jambu, parambe*, Tam.; *Jambi*, Tel.

A moderate-sized thorny tree, evergreen or nearly so, with light foliage and straggling rather slender branches armed with conical prickles. It does not ordinarily exceed a height of 40 ft. and a girth of 4 ft., the maximum attained being 50 ft. and 6 ft. respectively. The bole is usually short and is rarely straight; spines persist on the bole until it reaches a girth of about 1½ ft. Bark up to 1 in. thick, grey, rough with longitudinal furrows and transverse cracks. Wood very hard, heartwood dark brown; it makes excellent fuel and charcoal, and is used locally for various purposes. The pods contain a dry sweetish pulp, and are used as food for cattle.

Distribution and habitat. This tree occurs in the dry and arid regions of India, namely in Sind, the Punjab plains, Baluchistan, Rajputana, Guzerat, the Deccan, and the drier parts of southern India; it extends into Persia.

In Sind *Prosopis spicigera* is one of the principal species on the higher and older alluvium in the region of the Indus. Although found to a greater or less extent both in upper and in lower Sind, it may be considered to be the most characteristic species in the former just as babul (*Acacia arabica*) is in the latter: this is probably due partly to the greater intensity of frost in upper Sind, which is more harmful to *Acacia arabica* than to *Prosopis*, and partly to the fact that the duration of river inundations is longer and their

extent greater in lower than in upper Sind, the babul being favoured by these moister conditions. The occurrence of *Prosopis spicigera* marks one of the successive stages between that in which new alluvial ground is formed in the river-bed and the time when, owing to the receding of the river, this land is left high and dry above the reach of even abnormal river floods. The flood season of the Indus commences about the beginning of May, with the melting of the Himalayan snows, and the river continues to rise, with occasional interruptions, until July or sometimes later; thereafter it subsides gradually and reaches its winter level as a rule about the end of October. In the course of the annual floods much land is lost by erosion, while corresponding new land is won by accretion. The newest so-called *kacha* alluvium thrown up by deposits of silt becomes quickly covered with *Tamarix dioica* and *T. Troupii*, and a growth of *kanh* grass (*Saccharum spontaneum*): as the ground becomes more elevated *Populus euphratica* and *Acacia arabica* make their appearance, while later, when the land becomes elevated above the reach of all but abnormal floods, *Prosopis spicigera* becomes the prevailing species, having already gained a footing with the aid of the river floods and having survived after the preceding species have gradually disappeared. This, however, is not the final stage, for although its long taproot and its power of reproduction by root-suckers enable it to outlive its predecessors it is not strictly a desert species, and though it lingers for a long time on the older higher and drier alluvium it eventually gives place in the driest tracts to more typical desert species such as *Capparis aphylla*, *Salvadora oleoides*, and *S. persica*.

While often gregarious, particularly in upper Sind, *Prosopis* is frequently associated by single trees or small groups with the various species which precede it on the one hand and succeed it on the other. Thus, before it meets the desert species it may be found with *Tamarix dioica* and *Troupii* (sometimes in the form of moribund remnants), *Acacia arabica*, *Populus euphratica*, and *Tamarix articulata*, the largest species of *Tamarix*, which is characteristic of drier ground than the other two: again, on the older and drier alluvium *Prosopis* is commonly associated with the desert species already mentioned, with or without surviving individuals of the other species.

The soil on these alluvial tracts consists of varying mixtures of sand and clay. A special feature, indicative of deterioration of the soil through lack of surface drainage, is the presence of tracts of varying extent in which the soil is charged with an excess of sodium salts, these salts appearing as a white efflorescence on the surface of the ground. Where the soil becomes very saline *Prosopis*, in common with most other species, quickly dies out; on pure sand, also, it does not survive long.

In the Punjab *Prosopis spicigera* occurs throughout the alluvial plains from the Salt Range to the Sutlej river, but does not extend into the hills. By far the largest tracts are situated in the arid regions in the south-west of the province in the Multan and Montgomery districts. According to Mr. B. O. Coventry,[1] the area of these forests under the Forest Department in 1915 was about 3,500 square miles, of which about 2,700 square miles were in Multan, and about 700 square miles in Montgomery, the remainder being in the Lahore, Gujranwala, and Shahpur districts. There is little doubt that

[1] Ind. Forester, xli (1915), p. 307.

the area of forest was at one time far greater, and that it has been gradually curtailed by the extension of cultivation, a process hastened in recent times by the development of irrigation. This curtailment is still proceeding rapidly, and will continue to do so with the extension of irrigation, the natural dry forests giving place to cultivation and irrigated plantations, chiefly of *Dalbergia Sissoo*.

The five great rivers of the Punjab, of which the Indus is the chief, play an important part in the origin and the distribution of the *Prosopis* forests. These rivers, which are snow-fed, are liable to high floods when the Himalayan snows melt in the hot weather, and the process of annual flooding with attendant erosion and accretion proceeds in the manner already described for the Indus. The topography of the plains thus exhibits four main stages in the alluvial formation : (1) new alluvium in the river-beds ; (2) low land subject to inundation ; (3) higher ground beyond the reach of ordinary floods ; and (4) high so-called *bar* land forming the watershed between the rivers. The subsoil water-level varies from a few feet below ground surface in the low land near the rivers to as much as 100 ft. on the high *bar* land. The soil is a deep fertile loam with occasional hard pans of *kankar*, that is, concretionary calcareous deposits, a few feet below the surface, and with occasional unfertile tracts of saline soil locally known as *reh* or *kallar*. *Prosopis* regenerates on the low ground subject to floods, but not on the high *bar* land, and it owes its existence on the latter to the remarkable powers of survival due to its long taproot, which responds to the lowering of the water-level, and to its capacity for reproducing by root-suckers. Thus the conditions under which it is able to persist when once established are entirely unsuitable for its reproduction by seed, and it is further evident that this persistence may be of very long duration, perhaps, as Mr. Coventry remarks, for hundreds if not thousands of years.

On the high *bar* land *Prosopis* trees are as a rule somewhat scattered, and are usually associated with *Salvadora oleoides* and *Capparis aphylla*, while the two latter species often occur without *Prosopis*, which has gradually disappeared in course of time ; there are also frequently large blanks due to deposits of *kankar* or the presence of saline soil. Except for the tree growth the ground is bare of vegetation for several months in the year, though a fair crop of grass is produced during the rainy season. On the lower ground nearer the rivers the tree occurs gregariously in well-stocked crops ; here it is sometimes associated with *Tamarix* and with *Acacia arabica*.

In the Indian Peninsula the tree is not gregarious, but is scattered in open dry types of forest in association with *Acacia Catechu*, *A. arabica*, *A. leucophloea*, *A. eburnea*, *Chloroxylon Swietenia*, *Anogeissus latifolia*, *Zizyphus Jujuba*, *Z. Xylopyrus*, and other species. In some localities it occurs on black cotton soil with *Acacia arabica* and a few other kinds of trees.

In the most important areas of its distribution the climate is dry to arid, and is characterized by extremes of temperature, intense heat being a feature of the hot weather, while in the winter the thermometer may register a few degrees of frost. Within its region in Sind and the Punjab the absolute maximum shade temperature varies from 118° to 125° F., the absolute minimum from 25° to 40° F., and the normal rainfall from under 3 in. to about 25 in. or slightly over. In the Punjab plains it occurs most plentifully in the drier

regions where the normal rainfall is from 5 to 10 in. In Baluchistan it experiences lower temperatures than it does in Sind and the Punjab. In the Indian Peninsula it occurs in regions where the absolute maximum shade temperature varies from 105° to 115° F., the absolute minimum from 40° to 60° F., and the normal rainfall from 20 to 35 in.

Leaf-shedding, flowering, and fruiting. The foliage becomes somewhat thin towards the end of the cold season. The spikes of small yellow flowers appear from March to May, after the new leaves. The pods ripen from June to August; they are indehiscent, 4–8 in. long, slender, contracted between the seeds, filled with a dry sweetish pulp, and contain 10–15 seeds. The seeds (Fig. 151, *a*) are 0·2–0·3 in. by 0·15–0·2 in., compressed, ovate oblong or rhomboidal, brown, smooth, hard, with a moderately hard testa. The seed retains its vitality for at least a year.

Recent experiments in the Montgomery district with seed from coppice-shoots 5–11 years old showed that such seed was sufficiently fertile and that seed from the younger shoots was as fertile as that from the older ones. Ordinarily the seed, if watered, germinates from one to two weeks after sowing. The seed is distributed partly by water, partly by birds, and partly by cattle and other animals, which eat the sweetish pulp of the pods and void the seeds.

Germination (Fig. 151, *b–e*). Epigeous. The radicle emerges and the hypocotyl elongates by arching, carrying the cotyledons above ground when it straightens; as a rule the testa is carried up over the cotyledons, falling with their expansion.

The seedling (Fig. 151).

Roots: primary root long, thin, terete, tapering, wiry, yellow turning brown: lateral roots few, short, fibrous, distributed down main root: nodules present. *Hypocotyl* distinct from root, 0·8–1·4 in. long, terete, expanded in a ring at the base, white turning green, glabrous, smooth at first, soon becoming striate by cracks in the epidermis. *Cotyledons* very shortly petiolate, 0·5 by 0·4 in., elliptical ovate, apex rounded, base sagittate, foliaceous, somewhat fleshy, upper surface convex, lower concave, green, glabrous, 5-veined from the base, the two lateral veins very indistinct. *Stem* erect at first, soon branching and becoming straggling, zigzag at the nodes, wiry, glabrous, green or reddish, covered with prickles which are at first minute, later 0·1 in. long; internodes 0·2–0·3 in. long. *Leaves* alternate. Stipules 0·2 by 0·1 in., falcate, mucronate, green. First leaf pinnate, rachis 0·5 in. long, with occasional rudimentary or minute prickles, leaflets usually in five pairs, opposite, with very short petiolules, 0·2 by 0·1 in., obliquely oblong, mucronate, entire. Subsequent leaves bipinnate with one pair of opposite pinnae; common rachis 0·1–0·2 in. long, pinnae 0·3–0·6 in. with 4–6, later 7–8, pairs of leaflets similar to those of first leaf.

Under ordinary conditions the growth of the seedling is slow, though by irrigation and weeding more rapid development can be secured. In Sind, even in the case of irrigated sowings, the seedlings normally attain a height of only 6 in. to 1 ft. by the end of the first season. The seedling tends to assume a straggling growth, developing long side branches at the expense of height-growth. It forms a long wiry taproot, which by the end of the second season may attain a length of as much as 2½ ft. or more: this helps it to establish itself in the dry regions in which it grows. Young plants are somewhat sensitive to frost, and small weakly plants are liable to die back to ground-level owing to

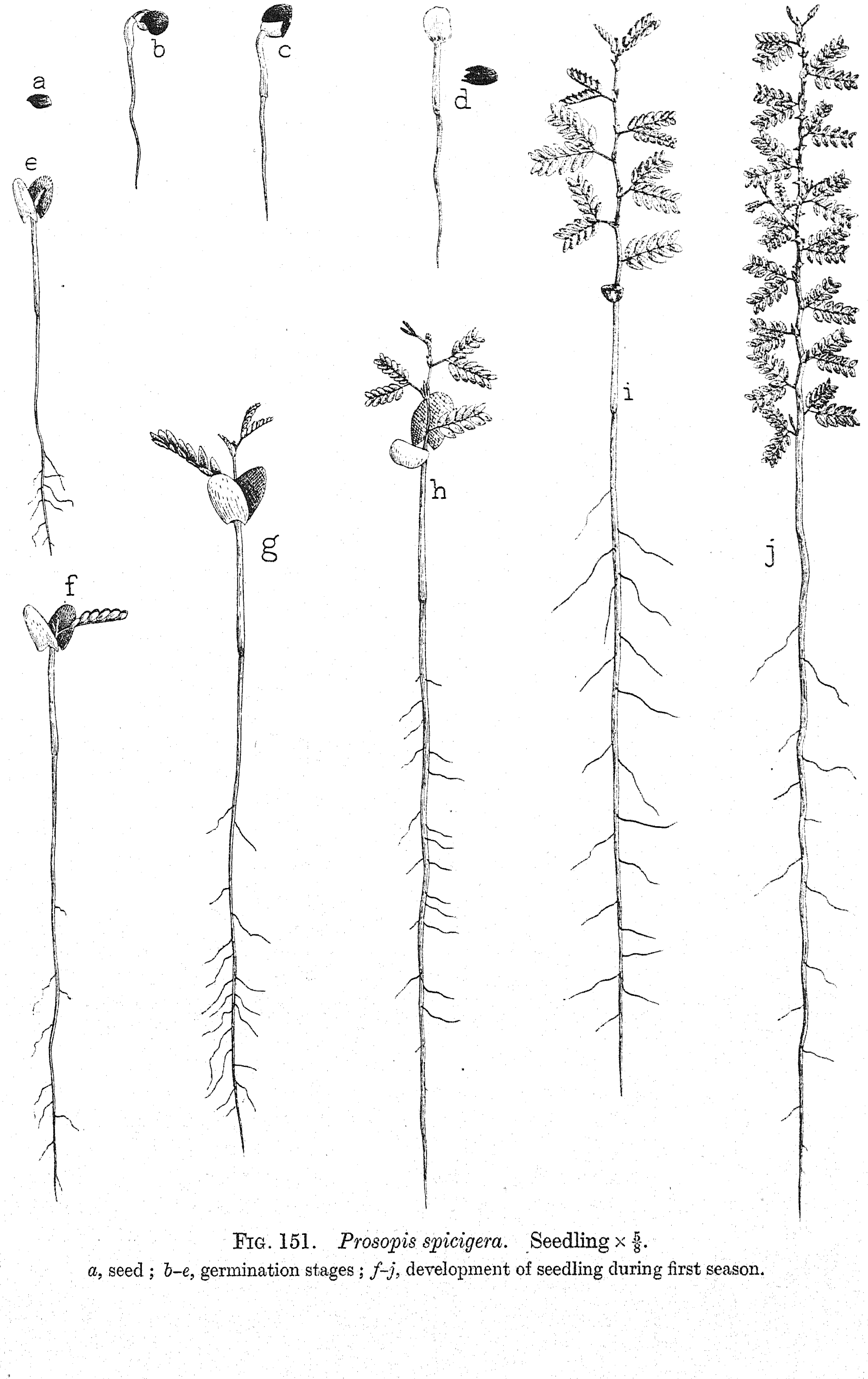

Fig. 151. *Prosopis spicigera*. Seedling × $\frac{5}{8}$.
a, seed ; *b–e*, germination stages ; *f–j*, development of seedling during first season.

drought; such plants, if they survive, are apt to assume for a time a bushy form owing to the development of new shoots from the lower portion of the stem. In the natural home of the tree, rats are often very destructive to young plants, gnawing them just below the ground-level; in seasons of low inundation, when the rats become numerous, their ravages are worst. The leaves of seedlings fall during the cold season, the young plants being leafless for a time towards the end of that season.

The following measurements of seedlings grown in experimental plots at Dehra Dun (which, however, is outside the natural habitat of the tree) compare to some extent the growth under varying treatment:

Growth of *Prosopis spicigera* seedlings under varying treatment, Dehra Dun.

	Condition under which grown.	Height at end of season. 1st season.	2nd season.	3rd season.
	(1) In nursery, weeded and watered	0 ft. 1 in.–0 ft. 3 in.	Maximum 0 ft. 5 in. (side branches up to 1 ft. 7 in. long)	0 ft. 3 in.–0 ft. 8 in.
	(2) In nursery, weeded and watered	Maximum 0 ft. 6 in.	Maximum 1 ft. 2 in. (with several straggling branches)	
Adjacent.	(3) Broadcast sowing, irrigated, weeded	Maximum 0 ft. 8 in. (vigorous and numerous)	0 ft. 3 in.–1 ft. 9 in.	
Adjacent.	(4) Broadcast sowing, irrigated, unweeded	Maximum 0 ft. 5 in. (few, weakly)	1 ft. 1 in.–1 ft. 4 in. (only a few survived the weeds, but now over them and in good condition)	
Adjacent.	(5) Broadcast sowing, unirrigated, weeded	Maximum 0 ft. 4 in.	Maximum 1 ft. 0 in.	0 ft. 2 in.–0 ft. 9 in. (decrease due to damage by frost and drought).
Adjacent.	(6) Broadcast sowing, unirrigated, weeded	Maximum 0 ft. 7 in. (seedlings numerous)	0 ft. 2 in.–1 ft. 4 in. (seedlings numerous)	
Adjacent.	(7) Broadcast sowing, unirrigated, unweeded	Maximum 0 ft. 7 in. (seedlings few)	(all killed by frost or suppression)	

Silvicultural characters. The tree is a decided light-demander. Although the seedlings are sensitive to frost and drought, older plants are very drought-resistant and stand frost better than *Acacia arabica*. Although it resists ordinary frosts within its habitat, it suffered somewhat in the Punjab plains during the abnormal frost of 1905. A most important characteristic of the tree is the extremely long taproot which it develops; this enables it to retain possession of the ground, in the dry regions which it inhabits, by obtaining its water-supply deep down in the subsoil. Gamble [1] mentions a specimen of a taproot, exhibited at Paris in 1878, which was 86 ft. in length, and had penetrated vertically for 64 ft. Mr. Navani [2] mentions a taproot which was dug up in Sind and found to measure 117 ft. in length.

[1] Man. Ind. Timbers, 1902, p. 288.

[2] Revised Working Plan for the Jerruck Forest Division, Sind, 1915.

The tree coppices well up to a moderate age, but old trees usually coppice badly or fail to coppice. Prolonged inundation is harmful to coppice, and it is therefore advisable to cut the stools high in places liable to be flooded for long; otherwise the coppice grows vigorously on irrigated forest land. In dry localities the stools sometimes become covered with the mounds of white ants, but although the growth of the coppice is thus checked, growth is carried on by root-suckers produced around the stump.

The tree reproduces freely by root-suckers, a form of reproduction which is of great importance in enabling it to survive long after its original associates have disappeared, and to reproduce itself freely after conditions have become impossible for reproduction by seed. Although the production of root-suckers is apparent everywhere, it seems to be most active where the water-level is comparatively near the surface; on high ground where the water-level is deep root-suckers appear for the most part close round the parent stem, and develop slowly. Felling, particularly if the stumps are grubbed out, appears to stimulate the production of suckers: on land cleared for cultivation the roots left in the ground reclothe the area with a flourishing crop of suckers which require to be dug out again. Fires in the grassy areas of riverain tracts also stimulate the production of suckers.

In some localities the tree is pollarded for camel and goat fodder: this induces rot, which spreads down into the bole, and it also frequently causes the appearance of numerous epicormic branches. The tree is readily browsed by camels and goats, and in areas open to goat browsing young plants assume a bushy growth, while a similar bushy growth often surrounds the bases of the trees owing to the browsing down of the root-suckers around them.

Natural reproduction. Experiments at Dehra Dun showed that under natural conditions the seed germinates at different times during the rainy season after heavy rain, some lying ungerminated until the second season. Germination and the establishment of the seedling are greatly assisted if the seed becomes slightly covered with soil; seeds washed into heaps in loose alluvial sand were found to germinate in quantity. If the seed germinates on the surface of the ground the radicle is apt to be eaten by insects or to dry up if there is insufficient moisture. In the dry weather following the rainy season there is much mortality among seedlings which have not succeeded in establishing themselves thoroughly.

In Sind and the Punjab natural reproduction by seed is confined almost exclusively to moist depressions and other places not far from the rivers, where the seedlings obtain occasional surface water and where the proximity of the subsoil water-level to the surface ensures soil moisture sufficient to enable the seedlings to establish themselves. This question of soil moisture appears to be all-important, for whereas on the lower ground near the rivers promising crops of *Prosopis* establish themselves from seed, on the high and dry ground away from rivers seedling reproduction is almost entirely absent, and the species has to depend on its remarkable power of reproduction by root-suckers to maintain its existence in these dry tracts. Here, although the seed may germinate successfully, the seedlings are unable to survive the drought.

In the riverain areas the young plants appear to resist suppression better than *Acacia arabica*, and are often found making their way through a fairly dense growth of grass where the latter species fails to establish itself.

Artificial reproduction. Various experiments carried out at Dehra Dun have shown that transplanting cannot be relied upon, but that direct sowings are successful if the seedlings are kept free from weeds and the soil is periodically loosened. Transplanting was tried both in the first and in the second rainy season, with entire as well as with pruned roots and stem, but failure resulted in each case.

In the dry parts of the Punjab plains, attempts have repeatedly been made to raise plantations by direct sowing without irrigation, but failure has resulted in every case, since the plants, just as in the case of natural seedlings, are unable to resist the drought. On the other hand, sowings artificially irrigated have proved quite successful, as in the case of the portion of the Changa Manga plantation known as the 'Jand extension', formed about the year 1885, and now a flourishing plantation of *Prosopis* several hundred acres in extent (see Fig. 152).

In Sind the tree has been successfully raised by sowings in conjunction with cereal crops on irrigated land. It has also been raised successfully by sowings on land which is subject to occasional floods but is too dry to support *Acacia arabica* permanently: these sowings require to be watered thoroughly during the first year, after which occasional watering is usually sufficient until the plants are established. Sowings of *Prosopis* in conjunction with field crops are carried out as a rule on the higher land above the reach of river floods, the lower land being devoted to the raising of the more valuable *Acacia arabica*. On these higher lands the system usually followed is to sow strips of *Prosopis* 4 ft. wide, with intervening strips 20 ft. wide sown with field crops. Irrigation is carried out by means of Persian wheels. Cultivation along with irrigation continues for two years; during the third year there is no cultivation of field crops, but irrigation is continued under agreement with the cultivator. After the third year the seedlings require no attention, but have to be protected against browsing animals. The field crops are the irrigated *kharif* crops sown in June together with the tree seeds and reaped in November; the crops commonly cultivated are the two millets *bajri* (*Pennisetum typhoideum*) and *jowari* (*Sorghum vulgare*), and sometimes sesamum, chillies, or other crops. The crops are irrigated from June to October. The field crops are assessed to revenue, and the cultivation is carried out under a regular agreement by which the cultivator is bound to protect the young plants from browsing and other injury during the three years in which they are under his care.

An experiment, which appears to have been successful, in planting up saline land with *Prosopis spicigera* and *Acacia arabica*, is described under the latter (p. 440).

Silvicultural treatment. It will be apparent from what has been said above that seedling reproduction is not obtainable in the plains of Sind and the Punjab except in riverain areas subject to occasional floods: hence throughout the higher tracts any system involving the retention of seed-bearers is out of the question.

In the Punjab the system in operation is simple coppice, and the rotation

FIG. 152. *Prosopis spicigera* plantation about 40 years old, Changa Manga, Punjab.

FIG. 153. *Xylia dolabriformis*, Burma.

commonly adopted is thirty years. In Sind the treatment followed, which is based primarily on the requirements of the principal species, *Acacia arabica*, is that of clear-felling with natural reproduction on the riverain alluvium, supplemented where necessary by artificial sowing, often with the aid of field crops; these sowings, as applied to *Prosopis spicigera*, have been described above. At one time a rotation of fifteen years was adopted, but as this was found to be too short it was raised subsequently to thirty years, which is the rotation prescribed in the more recent working plans. In the Sind coupes, reproduction of *Prosopis* is secured also by root-suckers and coppice-shoots.

It is many years since the stimulation of reproduction by root-suckers became the subject of observation and experiment in the Punjab. In 1881 'Punjabi',[1] recording his observations in the case of land cleared for cultivation where the stumps were respectively left in the ground and grubbed out, notes that in the latter case the resulting root-suckers were stronger and more numerous than in the former, and ascribes this in part to the fact that water lodges in the holes left after grubbing out the stumps and tends to keep the surrounding soil moist: these observations were subsequently confirmed by experiments made on forest land. The grubbing out of the stump and upper portion of the taproot, apart from its effect in stimulating the production of root-suckers, has the advantage of providing a considerable quantity of fuel and thus increasing the yield. The question of sucker reproduction is again alluded to in 1892 by Mr. C. F. Elliot,[2] who writes: 'It is some years since in the Punjab we recognized that the regeneration of *Prosopis spicigera* in the *bar* forests depends chiefly on root-suckers; at all events, that any improvement in the way of filling up blanks will be accomplished in this way and not by seed. . . . It is well known that these shoots from the roots of trees of which the stumps and main roots even have been dug out on the compartment lines are almost impossible to kill: year after year they have to be cleared away to keep the lines open.'

Rate of growth. *Seedling trees.* The growth of the seedling for the first few years is slow, but subsequent growth up to an age of about forty to fifty years is fairly rapid, particularly on land which is subject to periodical floods. In the original working plan of the Jerruck division, Sind, it is estimated that an average diameter of 10 in. is attained in 30 years.[3] In the Naushahro division, Sind,[4] countings of annual rings on stumps of seedling stems in riverain forest gave 3·1 in. diameter in six years, 5·1 in. diameter in eleven years, and 6·6 in. diameter in fourteen years. In partially inundated areas the growth was faster, namely 6 in. diameter in nine years, and 7·5 in. diameter in fourteen years.

Coppice-shoots. Mr. B. O. Coventry [5] estimates that coppice-shoots in the Punjab attain a height of about 30 ft. in fifteen years, with a girth of 2 to 3 ft. in good localities, and that the out-turn of fuel per acre varies from 100 to 1,000 cubic ft. and averages 300 cubic ft. stacked. The following measure-

[1] Ind. Forester, vi (1880–1), p. 327. [2] *Ibid.*, xviii (1892), p. 305.
[3] Working Plan for the Jerruck Division, Sind, A. C. Robinson, 1899.
[4] Working Plan for the Forests of the Naushahro Division, Sind, A. C. Robinson, 1900.
[5] Ind. Forester, xli (1915), pp. 310–11.

ments of vigorous and fairly vigorous coppice-shoots in Multan are recorded by Mr. A. L. McIntire: [1]

Prosopis spicigera: coppice measurements, Multan.

Age.	Diameter.	Out-turn of thick wood over 2 in. in diameter per stool.
years.	in.	cubic ft. stacked.
5	1 to 2·5	—
10	3 to 5	1 to 10, av. 4
15	5 to 7 or 8	6 to 18, av. 10
20	6 to 9 or 10	10 to 30, av. 20

Experimental coppice fellings in the Montgomery district were carried out in 1912 in different months from April to November; measurements made on January 10, 1915, showed that shoots obtained from trees felled from April to August (i.e. aged two years five months to two years nine months) varied in height from 6 ft. to 12 ft. 6 in., whilst those from trees felled from September to November (i. e. aged two years two months to two years four months) varied in height from 4 ft. to 7 ft. 8 in.[2]

Measurements made in 1899–1900 in annually inundated riverain coppice coupes in the Naushahro forest division, Sind, gave the following results: [3]

Prosopis spicigera: measurements of riverain coppice, Naushahro, Sind.

Forest.	Age 3 years. No. of stems measured.	Age 3 years. Mean girth at 1 ft. from ground-level.	Age 4 years. No. of stems measured.	Age 4 years. Mean girth at 1 ft. from ground-level.
		in.		in.
Mohbat Dero . .	29	5·9	39	9·5
Bhour . . .	60	6·2	81	9·5
Bhorti . . .	25	5·9	34	9·5

In the Jerruck division of Sind it is estimated that coppice-shoots 4–8 in. in diameter are produced in fifteen years.[4]

The following measurements, made in 1901–2, of 2,073 coppice-shoots in the Sukkur division of Sind, show the average rate of growth in riverain and dry forests respectively: [5]

Prosopis spicigera: coppice measurements, Sukkur, Sind.

Age.	Mean diameter. Riverain forests.	Mean diameter. Dry forests.
years.	in.	in.
2	1·77	1·20
3	2·48	1·72
4	3·65	2·43
5	4·25	2·89
6	5·17	3·51

[1] Working Plan for the South Kabirwala and Mailsi Forests, Multan, 1899.
[2] Punjab Forest Conference Proceedings, 1915, p. 17.
[3] Working Plan for the Forests of the Naushahro Division, Sind, A. C. Robinson, 1900.
[4] Working Plan for the Forests of the Jerruck Division, Sind, A. C. Robinson, 1899.
[5] Working Plan for the Forests of the Sukkur Division, Sind, A. C. Robinson, 1903.

The following coppice measurements in Baluchistan are recorded in the Forest Report of that province for 1915–16:

Prosopis spicigera: coppice measurements, Baluchistan.

Age.	Maximum height.		Forest.
years.	ft.	in.	
4	5	8	Gullushahr
8	20	1	Abdulla Kheli
9	22	2	—
10	22	0	—
11	22	10	—

2. **Prosopis juliflora,** DC. Var. *glandulosa*, Sarg. Syn. *P. glandulosa*, Torr.; *P. pallida*, H. B. and K. Mesquit bean.

This species is very variable: the variety *velutina*, Sarg., is said to be the more useful timber variety, the tree reaching a height of 50 ft. and a diameter of 2 ft. (cf. R. S. Hole in *Ind. For. Records*, vol. iv, pt. iii). *P. juliflora*, DC., the typical variety (or species) is a small evergreen tree, usually unarmed; it is cultivated in northern India, but not extensively. Var. *glandulosa*, Sarg. (*P. glandulosa*, Torr.), is a small or moderate-sized deciduous tree armed with stout scattered axillary thorns: it appears to have been first introduced into India in 1877 from seed obtained through Kew, and in some of the drier parts of India has proved of great importance for afforestation work, for which purpose it deserves further attention. It is recommended for planting shifting sands in dry localities. It is also a useful source of supply of fuel, of famine fodder, and of food for man in times of scarcity, the pods being sweet and edible.

Its natural distribution, according to Bentham,[1] is 'west tropical and sub-tropical North and South America; very abundant from Buenos Ayres and Chile, along the Andes, to Mexico and Texas, and frequently planted'. In North America it is 'one of the characteristic trees of the lower Sonoran Zone, an area where the conditions as to rainfall and climate range from arid to semi-arid, that is, the rainfall varies from less than 10 to about 25 in. per annum'.[2]

In Jamaica the tree is known as 'cashaw', and is described as 'an admirable tree (often attaining a height of 40 to 60 ft.) to grow in dry gravelly soil, and in situations where rain does not fall for months together. It is fast growing: the timber is excessively hard and of a remarkably durable character. It is used for making knees of boats and all work requiring strength and tenacity. Posts of cashaw in wire fences last longer than any other, and are in great request for that purpose. . . . The pods are of a sweetish succulent character eagerly sought for by cattle: indeed in some parts of this island during droughts they subsist largely on them.'[3]

In India it has succeeded admirably in dry regions, reproducing sometimes in profusion by seed and by root-suckers: in damp localities, however, the seedlings are apt to die off in the first rains, being susceptible to an excess of moisture. In Sind it has proved a most useful sand-binder, and has been grown there since 1878. It may be seen growing in profusion about Miani

[1] *Mimoseae* in Trans. Linn. Soc., vol. xxx, 1874.
[2] U. S. Dept. Agric. Bull. 16, J. G. Smith, 1899, p. 18.
[3] Ind. Forester, x (1884), p. 293.

near Hyderabad. For many years inroads of drifting sand gave much trouble in this place, but it has reproduced naturally over the Miani plain through seed distributed by goats, which eat the pods; as a result it has fixed the sand and has formed an efficient screen against further inroads of drifting sand. It has also done well in Baluchistan, where it has been found to resist drought admirably.

In northern India the seed ripens in May and June. Seedlings can best be raised in flower-pots, several seeds being sown in each pot. When about 4 in. high they are transferred singly to small pots, and planted out in the monsoon, about August, after a good fall of rain. Direct sowings are also successful.

Mr. R. N. Parker has published the following interesting note on the tree in the Punjab:[1]

'One striking peculiarity about the plant is that wherever large specimens are seen in dry and arid districts, natural seedlings are almost sure to be found in abundance in the immediate neighbourhood. The tendency of *P. juliflora* to spread naturally may be seen on the unirrigated strip of land between the canal and the plantation at Changa-Manga. Here the rainfall averages 15 inches and the strip of land referred to carries a sparse growth of the trees which were found in this district before the plantation was made, *i. e. Prosopis spicigera*, *Capparis aphylla* and *Salvadora oleoides*. A few trees of *P. juliflora* were planted some years ago in this strip and they are spreading rapidly, the seedlings being in places so dense that it is difficult to walk through them. Cattle graze here daily, but plants within easy reach show no signs of having been browsed. Seedlings of the indigenous trees it may be remarked are conspicuous by their absence. *P. juliflora* keeps to the unirrigated ground and shows no inclination to spread into the plantation.

'In Khushalgarh, in what once was the compound of a P.W.D. building but which now is the most accessible portion of the village grazing ground, there are two *P. juliflora* trees about 2 ft. in girth and 25 ft. high. A few root-suckers of *Capparis aphylla* badly browsed by goats and a soft sandstone rock describes the growing stock and soil of the surrounding waste. The rainfall is, I believe, about 18 inches. In spite of these unfavourable conditions, seedlings of *P. juliflora* are plentiful around the large trees and extend some distance away into the village waste.

'In the Pabbi reserve *P. juliflora* has been successfully used in reboisement works and has made considerably faster growth than *Acacia modesta*, with which it has as a rule been mixed. Regeneration of *P. juliflora* is frequent in the Pabbi reboisement area, whereas natural seedlings of the indigenous trees are difficult to find. *P. juliflora* was tried many years ago at Gujranwala. I have not seen the original trees, but along the railway line all the way from Gujranwala to the Pabbi Hills natural seedlings of *P. juliflora* may be seen at frequent intervals. *P. juliflora* has certainly come to stay in the Punjab and it is likely to be a common tree in all the drier districts in time.

'I have grown *P. juliflora* on a small scale almost every year since 1906, mainly without much success, but as failures often teach us more than success, I mention some of them. In 1906–07 I tried *P. juliflora* at Nurpur, district Kangra. The plants grew well as long as they were in pots, but on being planted out they did badly and none were left when I visited Nurpur in October 1912. In Nurpur the rainfall is 67 inches, but the plants were tried in a dry well-drained place. In the winter of 1907–08 I planted some plants in a hedge of Agaves at Phillaur. The plants were not watered at all, but I saw them on the 30th June, 1908 (the rains broke next day), and found them all doing

[1] Ind. Forester, xxxix (1913), p. 320.

well. I looked for these plants when I next visited Phillaur in July 1912, but found very few left, and these had made poor growth. A few hundred yards off there was a natural seedling of *P. juliflora* growing in a field, and the growth made by this plant in the four years 1908–12 was very marked. The rainfall in Phillaur is about 30 inches. In 1909 I tried *P. juliflora* in a grassy blank in one of the scrub forests in Hazara. I saw the sowings about a year later and found that the plants had made very poor growth and gave little promise of surviving. In this case the rainfall was 30–40 inches.

'The spread of *P. juliflora* over grass-lands in parts of America has been attributed to the stocking of the country with cattle, which graze down the grass and weaken it, and thus enable the tree to compete successfully against it. In the cases of failure with *P. juliflora* mentioned above there was a fairly heavy grass growth and protection from grazing, and it seems that this may have been responsible for the bad results. The rainfall could not have been responsible except perhaps indirectly by favoring the growth of other plants, as the natural seedling in Phillaur showed. This seedling was in a place where grass and jungle were kept down by cattle. Cattle and even goats seem to do little harm to *P. juliflora*, and I have often been surprised to see the leaves untouched, although within easy reach of cattle and at a time when there is little green fodder available.

'As regards frost-hardiness, I have seen seedlings pass through a winter at Abbottabad (4,000 ft.) uninjured, so that it may be regarded as quite hardy anywhere in the plains of India.

'The habit of *P. juliflora* is peculiar: most of the trees and all the natural seedlings I have seen branch at ground level, giving several crooked branches. . . . There is, however, an erect form, and the two big specimens in Khushalgarh had an upright habit not unlike that of *Acacia arabica*. This form, however, is not constant, as the seedlings from the Khushalgarh trees all showed the usual crooked habit.

'As regards the rate of growth of *P. juliflora*, G. B. Sudworth says in "Forest Trees of the Pacific Slope": "The tree is unquestionably long lived, though of exceedingly slow growth. Trunks 10–12 inches in diameter are from 100 to 125 years old, while the larger trunks occasionally found are likely to be very much older." This does not apply to the tree in India, as it has only been introduced some 35 years, and specimens 6–8 inches in diameter are not infrequent. . . .

'As a drought-resister I know of no tree to equal *P. juliflora*. It has been used with success to clothe some old brick-kiln mounds in the Government Agri-Horticultural Gardens, Lahore. The average rainfall in Lahore is 19 inches, and of this a large portion usually falls in heavy showers on one or two days in the year and runs off the steep slopes of the mounds so that the trees have to manage with considerably less than 19 inches of effective rain. Two years in succession of deficient rain has caused some of the plants on the top of the mounds to lose the tips of their shoots, but although there must be fully 100 specimens I have not seen a single one that has died of drought. On the very top of one of these mounds a sowing was made in 1911. The seedlings were not watered, and the rainfall in 1911 and 1912 was 13 and 14 inches respectively. When I last saw the place about a month ago, a good many plants were left. The place is much frequented, and the survivors all showed signs of having been trodden on, so that it is quite likely that those which died, died from having been trodden on and not from deficient moisture. Mr. Brown, Superintendent of Farms, N.-W. F. Province, tells me he has *P. juliflora* growing luxuriantly on the crest of a dry bank near Peshawar. The plants were planted in February 1911, and were not watered; the rainfall in 1911 amounted to 13 inches, and to 8 inches in 1912. The ability of this plant to withstand drought is astonishing, especially as it comes into leaf early in April and remains green right through the hot weather.

'. . . Any one who has collected seeds of Indian Acacias or Albizzias must have noticed the large proportion attacked by insects. With *Acacia modesta* in the Punjab it is not uncommon to find fully half the seed crop destroyed by weevils. In the case of *P. juliflora* seed collected in India, I have never seen a single seed attacked. To this is perhaps largely due the profuse reproduction of *P. juliflora* in suitable localities as compared with the indigenous trees. During the past 18 months I have received several consignments of *P. juliflora* seed from Mexico, and in each case found a very large proportion of the seed destroyed by weevils. It is evident that *P. juliflora* on being brought to India has left its natural enemies behind. The publicity given to the merits of this tree may perhaps lead to fresh consignments of seed being imported from America, and if this is done, care should be taken to see that the weevils are not introduced too. As seed is produced in abundance in India there is no need to import it from America, unless the object be to obtain other varieties than var. *glandulosa*. Last year over 60 maunds of seed was collected in the Pabbi Reserve, and several maunds could be collected annually in Lahore or Changa-Manga.'

2. XYLIA, Benth.

Species 1. *X. dolabriformis*, Benth.; 2. *X. xylocarpa*, Roxb.

1. **Xylia dolabriformis,** Benth. Ironwood of Burma, pyinkado. Vern. *Pyinkado, pyin*, Burm. (Fig. 153.)

A very large deciduous tree. Leaves bipinnate with one pair of pinnae, each pinna with two to six pairs of leaflets. Bark thin, yellowish or reddish grey, fairly smooth, exfoliating in irregular rounded plates. Wood reddish brown, very hard, heavy and durable, extensively used for house and bridge construction and for railway sleepers; it is one of the most important timbers in Burma.

Under favourable conditions the tree reaches a height of 120 ft. and a girth of 12 ft. or more, but on poor ground it is stunted.

Distribution and habitat. Throughout the greater part of Burma and Arakan, ascending to 3,000 ft. In the Irrawaddy valley it extends as far north as 24° N. lat., being locally common in some of the forests of the Shweli river drainage: in the Chindwin valley it extends somewhat farther north, though its northernmost limit has not yet been accurately determined. It extends southward into Tenasserim, eastward into the Shan States, and westward into Arakan. It is probably most abundant, as well as most accessible, in the extensive forests of the Pegu Yoma, the low range of hills running up the centre of Burma and forming the watershed between the Irrawaddy and Sittang rivers. It is found in parts of the dry zone of Upper Burma, but here it does not attain large dimensions. In Arakan it occurs in many localities, often in belts or patches of varying extent. The quality is best in the Sandoway district, where the percentage of pyinkado in the crop is usually higher than it is in most parts of Burma; on the islands, and in the eastern part of the Akyab district, the trees are often stunted and badly shaped.

Pyinkado is found both on hilly and on flat ground, but particularly on the former, attaining its best development on the lower slopes of hills and in well-drained valleys. It thrives best on deep moist porous loam and requires good drainage, for which reason its occurrence on flat ground is decidedly local, being confined to well-drained areas, preferably with a slightly undulating

surface ; it avoids low-lying flat ground subject to inundation. The tree is found on a variety of geological formations. On the sandstones and shales of the Pegu Yoma, producing a deep sometimes sandy loam, it thrives extremely well. In the Chindwin valley it is found, often of large size, on sandstone and conglomerate with occasional shale, clay, or limestone. In the Ruby Mines district it occurs to some extent on limestone, sandstone, slate, and shale. Mr. G. R. Jeffery [1] attributes its local occurrence in this district to the fact that it avoids saline and ferruginous soils : thus, although it is present and abundant in the Hintha and Ôndôk blocks, it is wholly absent from the neighbouring Kyauktaung block, where the soil is largely saline and ferruginous. In the Madaya drainage of the Mandalay district it occurs on gneiss and occasional limestone, while east of the Sittang river it is found on gneiss and granitic schist. In the Thaungyin valley of Tenasserim it occurs on argillaceous sandstones and shales, on igneous or metamorphic rocks and on limestone. In various localities it grows on recent alluvium, provided the drainage is good. In the dry zone of Upper Burma it is found to a very limited extent and of small size on sandstone with alternating thin bands of shale. Throughout its distribution it occurs locally and in stunted form on laterite in the dry dipterocarp forest known as *indaing*.

In the natural habitat of the tree the absolute maximum shade temperature varies from 100° to 113° F., and the absolute minimum from 40° to 55° F. As regards rainfall requirements, it is actually found in limited quantity in the dry zone of Upper Burma in places where the normal rainfall is as low as 30 in., though here it reaches only a small size. It may be said in general that where the rainfall is less than 45 in. it does not attain large dimensions, while it grows best with a rainfall of 60 in. and over ; actually it is known to grow extremely well with a rainfall of 120 in., and no doubt it thrives in even wetter localities.

The tree occurs in five broad types of forest : (1) upper mixed deciduous forest ; (2) lower mixed deciduous forest ; (3) evergreen forest ; (4) *indaing* forest ; and (5) scrub forest of the dry zone.

1. Upper mixed deciduous forest. This is by far the most important type, and the one in which the trees are found in the greatest abundance and attain the largest dimensions. This type is characteristic of hilly country, the hills being often little more than comparatively low spurs, as on the outer fringes of the Pegu Yoma (see Fig. 155) : it is the type which comprises the great bulk of the more important teak forests of Burma, and is in the great majority of cases characterized by the presence of bamboos. There are many sub-types of this type ; these can be classified to a large extent according to the moistness or dryness of the forest, the bamboos being the best indicators. The moistest sub-type is that which verges on evergreen, and often contains little or no teak ; in this sub-type, which is well developed in the moister regions of the Pegu Yoma, pyinkado is sometimes so abundant as to become practically gregarious. This sub-type merges into the typical moist mixed deciduous sub-type and thence through various stages into the driest sub-type of mixed deciduous forest. The typical bamboo of the driest sub-type is

[1] Working Plan for the Hintha, Ôndôk, and Kyauktaung Reserves, Ruby Mines Division, 1908.

Dendrocalamus strictus, while *Bambusa Tulda* is also found in dry forest, though it extends also into the moister sub-types. Other typical bamboos of the upper mixed deciduous forests are *Bambusa polymorpha*, *Cephalostachyum pergracile*, *Oxytenanthera albociliata*, *Dendrocalamus longispathus* (moist valleys in the Pegu Yoma), and *Thyrsostachys Oliveri* (Upper Burma). The pyinkado probably reaches its finest development in upper mixed forest of the moister sub-type, in which *Bambusa polymorpha* grows in greatest luxuriance. In the Pegu Yoma some of its more important associates in the upper mixed type are *Tectona grandis*, *Lagerstroemia Flos-Reginae*, *L. tomentosa*, *L. villosa*, *Homalium tomentosum*, *Terminalia tomentosa*, *T. Chebula*, *T. pyrifolia*, *Sterculia* spp., *Adina cordifolia*, *A. sessilifolia*, *Stephegyne diversifolia*, *Bombax insigne*, *Spondias mangifera*, *Odina Wodier*, *Dalbergia cultrata*, *D. ovata*, *Pterocarpus macrocarpus* (in dry forest), *Cassia Fistula*, *Albizzia odoratissima*, *Acacia Catechu* (in drier types), *Schleichera trijuga*, *Berrya Ammonilla*, *Eugenia Jambolana*, *Gmelina arborea*, *Vitex pubescens*, *V. glabrata*, *Premna tomentosa*, and *Anogeissus acuminata*. In moist types verging on evergreen forest *Dipterocarpus alatus* makes its appearance, while in the drier types approaching *indaing* in character the most important trees are *Pentacme suavis* and *Shorea obtusa*. There is a further variety of dry forest without bamboos, exemplified in parts of the Pegu Yoma, locally known as *thitkyin* forest, which is characterized by an extremely plentiful advance growth of pyinkado, and in which the most characteristic species, apart from *Xylia*, are *Tectona grandis*, *Terminalia tomentosa*, *Homalium tomentosum*, and *Lagerstroemia Flos-Reginae*.

In the Chindwin drainage most of the above-mentioned species are also found. In the southern part of this drainage *Acacia Catechu* and *Pterocarpus macrocarpus* are fairly common. The chief bamboos are *Cephalostachyum pergracile*, *Dendrocalamus strictus*, *Bambusa Tulda*, and *Dendrocalamus Brandisii*. *Bambusa polymorpha* is very rare and local.

In the Ruby Mines district pyinkado, though somewhat local, is plentiful in some localities. It is found in three main types of forest: (i) on fertile sometimes rather dry slopes with *Tectona grandis*, *Terminalia tomentosa*, *T. Chebula*, *Vitex pubescens*, *V. alata*, *Pterocarpus macrocarpus*, *Anogeissus acuminata*, *Adina cordifolia*, *Pentacme suavis*, *Odina Wodier*, *Sterculia versicolor*, *S. villosa*, &c., the chief bamboos being *Dendrocalamus strictus*, *Thyrsostachys Oliveri*, and *Cephalostachyum pergracile*; (ii) on flats in bends of streams with *Tectona grandis*, *Lagerstroemia Flos-Reginae*, *Tetrameles nudiflora*, *Adina cordifolia*, *Anogeissus acuminata*, *Terminalia tomentosa*, and *Pterocarpus macrocarpus*, the chief bamboos being *Bambusa Tulda* and *Oxytenanthera albociliata*, and there is often a dense undergrowth of thorny climbers; (iii) in poor open bamboo forest, chiefly of *Dendrocalamus strictus*, and occasionally *Thyrsostachys Oliveri* and *Cephalostachyum pergracile*, on dry shallow soil, where the trees attain small dimensions; here the principal associate species are *Terminalia tomentosa*, *T. Oliveri* (in drier parts), *Pterocarpus macrocarpus*, *Diospyros burmanica*, *Acacia Catechu*, *Adina cordifolia*, *Odina Wodier*, and others, and there is often a dense thorny undergrowth of such shrubs as *Harrisonia Bennettii* and *Cratoxylon prunifolium*.

In the Madaya drainage of the Mandalay district pyinkado is associated with numerous deciduous species, such as *Tectona grandis*, *Pterocarpus macro-*

carpus, *Terminalia tomentosa*, *Gmelina arborea*, &c., with *Pentacme suavis* and *Shorea obtusa* in the drier parts; the chief bamboo is *Thyrsostachys Oliveri*, with *Dendrocalamus strictus* on dry areas.

In the Thaungyin drainage of Tenasserim the most important pyinkado tracts are the semi-moist and dry mixed teak-bearing forests, which are found partly on hill slopes and ridges and partly on flat alluvial ground with sandy soil along the Thaungyin river; in the former areas *Dendrocalamus strictus* is the prevailing bamboo. Pyinkado of large size is plentiful in all the semi-moist forests, especially along the Thaungyin river, its chief associates being *Tectona grandis*, *Terminalia tomentosa*, *Lagerstroemia Flos-Reginae*, *L. tomentosa*, *Adina cordifolia*, *Gmelina arborea*, *Pterocarpus macrocarpus*, *Homalium tomentosum*, and *Odina Wodier*; the principal bamboos, besides *Dendrocalamus strictus*, are *Oxytenanthera albociliata*, *Dendrocalamus Brandisii*, *Cephalostachyum pergracile*, *Bambusa Tulda*, and *B. arundinacea*. Pyinkado is also found to a limited extent in moist forest containing no teak, which occurs chiefly on the higher moist slopes on the east of the Meplê-Thaungyin watershed; this forest is characterized by a dense undergrowth of bamboo, chiefly *Oxytenanthera albociliata*.

2. Lower mixed deciduous forest. So far as pyinkado is concerned this type is of less importance than the upper mixed forest. It occurs on the flat usually alluvial ground of the plains, and merges to some extent into the upper mixed type or into evergreen forest or, where laterite occurs, into *indaing* forest. Pyinkado is not found on the low-lying portions of the alluvial plains, where the forest merges into savannah types, but occurs only where the drainage is good. Its chief companions are *Tectona grandis*, *Lagerstroemia Flos-Reginae*, *L. macrocarpa*, *L. tomentosa*, *Terminalia tomentosa*, *T. belerica*, *T. Chebula*, *T. pyrifolia*, *Homalium tomentosum*, *Adina cordifolia*, *A. sessilifolia*, *Stephegyne parvifolia*, *S. diversifolia*, *Careya arborea*, *Odina Wodier*, *Bridelia retusa*, *Eugenia Jambolana*, *Berrya Ammonilla*, *Eriolaena Candollei*, *Schleichera trijuga*, *Dalbergia cultrata*, *Anogeissus acuminata*, *Diospyros ehretioides*, *Vitex glabrata*, and *Dillenia pentagyna*. Bamboos are usually absent, though in some localities *Bambusa Tulda* occurs along watercourses.

3. Evergreen forest. Although tropical evergreen forest is very frequently found without pyinkado, the tree nevertheless occurs in this type, in common with other large deciduous trees such as *Tetrameles nudiflora*, *Sterculia alata*, *Artocarpus Chaplasha*, and *A. Lakoocha*, as well as lofty evergreen species such as *Dipterocarpus alatus*, *Hopea odorata*, *Anisoptera glabra*, and others, all these forming an upper story over a dense growth of evergreens of many species, with palms and canes. It is probable that this type represents in many cases a progressive succession from deciduous to evergreen forest, and this is borne out by the fact that pyinkado-bearing types intermediate between the deciduous and the tropical evergreen forest are met with, and that in the latter the pyinkado may be represented only by large trees which have survived from the former moist deciduous forest. Mr. A. E. Ross [1] notes an interesting fact regarding the encroachment of evergreen forest and its effect on teak and pyinkado in the forest of the lower Thaungyin drainage in Tenasserim. It was noted that on the edges of evergreen forest within the

[1] Working Plan for the Lower Thaungyin Working Circle, 1909.

fire-protected area the evergreen species appeared to be spreading. Several pyinkado, teak, and other moist forest species were found standing dead in the evergreen near its edge. Many of these trees still had their bark on and had evidently been choked for want of light. Farther in, dry stag-headed trees and fallen trees of these species were occasionally met with.

4. *Indaing* forest. This type of dry dipterocarp forest occurs on laterite or gravel, among its most characteristic species being *Dipterocarpus tuberculatus*, *Pentacme suavis*, *Shorea obtusa*, *Melanorrhoea usitata*, *Buchanania latifolia*, *Dillenia pulcherrima*, and *Diospyros burmanica*. Pyinkado is sometimes fairly plentiful in this type, but the trees are always stunted, and this forest cannot be regarded as an important pyinkado-bearing type.

5. Scrub forest of the dry zone. Pyinkado is not a typical tree of the dry zone of Burma, but is met with to a very limited extent in the better types of dry zone scrub forests on sandstone with alternating thin bands of shale, though it attains only small dimensions; its chief companions are *Pentacme suavis*, *Shorea obtusa; Terminalia tomentosa*, *T. Oliveri*, *Tectona Hamiltoniana*, *Acacia Catechu*, *A. leucophloea*, *Cassia renigera*, *Buchanania latifolia*, *Odina Wodier*, *Diospyros burmanica*, and *Schleichera trijuga*.

Some figures may now be quoted showing the prevalence of pyinkado in different forest tracts. The proportion of this species in the lower mixed forests is comparatively small, the highest percentage recorded being 9·4 for the Kangyi reserve of the Zigôn forest division. Some of the plains forests, however, owing to their accessibility, have been heavily worked in the past, and figures regarding these forests may be misleading: thus the Satpôk reserve in Tharrawaddy, with only 3 per cent. of pyinkado, contains numerous stumps of that species. The case of the upper mixed forests is different, for working plan enumerations have been carried out over extensive areas where pyinkado had not previously been worked, and the figures obtained indicate that in many cases, particularly in the moister types of mixed forest, pyinkado is more numerous than any other species, often approaching gregariousness. The following instances may be quoted of sample plots specially rich in pyinkado:

Forest division.	Forest.	Area of sample plot. acres.	Average number of pyinkado trees 3 ft. and over in girth per acre.
Pyinmana	Yeni	133·4	11·4
Nyaunglebin	Aingdon Kun	118·0	10·7
	,,	89·0	11·5
	,,	100·0	11·1
	West Kun	124·0	14·3
	Yenwe	104·0	10·9
Toungoo	Gwethe	68·8	11·0
Tharrawaddy	Kônbilin	41·0	11·5[1]

[1] Trees 1 ft. in diameter and over.

Outside the Pegu Yoma the richest pyinkado tract hitherto examined is the Nwa working circle of the Myittha forest division in the Chindwin drainage, where enumerations showed an average for the whole tract of 490 pyinkado trees 3 ft. and over in girth per 100 acres, this species forming no less than 24 per cent. of the total growing stock.

FIG. 154. *Xylia dolabriformis*—SEEDLING × $\frac{3}{8}$

a—Seed b - e—Germination stages f - j— Development of seedling to end of first season

The figures furnished by working plan enumerations in the Pegu Yoma are given in the statement on the next page. The figures no doubt contain many discrepancies owing to the inclusion in certain cases of Karen areas, teak plantations, or types of forest in which pyinkado is scarce or absent, but even allowing for these discrepancies the figures are interesting. The statement shows the various forest blocks on either side of the watershed placed opposite each other in their correct geographical positions. In this large unbroken tract of forest running north and south, measuring about 220 miles in length and averaging about 25 miles in width, the forest is of a dry type in the north, becoming moister towards the south; again, the forest on the western side is drier than that in the same latitude on the eastern side. The statement clearly shows in a general way the increase in the quantity of pyinkado on proceeding from the drier to the moister types, whether from north to south or from west to east.

LEAF-SHEDDING, FLOWERING, AND FRUITING. The leaves fall about February and the new leaves appear about April–May. The globose heads of small yellowish flowers appear in March–April, and the pods ripen next December–January, dehiscing on the tree, the hard woody valves bursting open elastically and curving back; the pods fall at the time of or not long after dehiscence, and have usually all fallen by May. The pods are 4 to 6 in. long by 2–2·5 in. broad, brown, flat, woody, falcate-oblong, containing six to ten seeds. The seeds (Fig. 154, *a*) are flat, ovate, oblong, or nearly orbicular, 0·4–0·7 in. by 0·35–0·5 in., brown, smooth, shining, with a moderately hard testa. The percentage of fertility is high, and germination takes place readily; the seeds retain their vitality well for at least a year if kept dry. Occasional bad seed-years occur, but good seed-years are frequent enough to secure ample regeneration where other conditions are favourable.

GERMINATION (Fig. 154, *b–e*). Epigeous. The radicle emerges and descends rapidly; the hypocotyl arches at first and elongates, soon straightening and raising the cotyledons above ground. The testa is either left in the ground or carried up over the cotyledons, dropping with their expansion.

THE SEEDLING (Fig. 154).

Roots: primary root long, moderately thick, terete, tapering, wiry, white or pale yellow at first, turning brown, glabrous or minutely pubescent when young: lateral roots fairly numerous, at first short, afterwards long, fibrous, distributed down main root. *Hypocotyl* distinct from the root, 1–2·3 in. long, terete, tapering slightly upwards or fusiform, white turning green, minutely pubescent. *Cotyledons*: petiole 0·1 in. long or less: lamina 0·7–0·9 in. by 0·5–0·7 in., broadly elliptical or obovate, apex rounded, base sagittate, entire, fleshy, glabrous, upper surface flat or slightly concave, lower surface convex, veins not distinct. *Stem* erect, woody, green turning brown, young parts pubescent; internodes 0·3–1·2 in. long. *Leaves* compound, first pair opposite, usually with one pair, rarely two pairs of leaflets, sometimes trifoliate, subsequent leaves alternate with 1, 2, or 3 pairs of leaflets; bi-compound leaves ordinarily commence to form in the second season. Stipules up to 0·2 in. long, linear lanceolate, acuminate. Rachis (first season) 0·6–5 in. long, pubescent, terminating in a fine bristle. Leaflets opposite, with petiolules up to 0·1 in. long, 0·7–5 in. by 0·25–2 in., ovate, acuminate, entire, glabrescent above, pubescent beneath, terminal pair larger than remaining leaflets, young leaves often copper-coloured.

Prevalence of *Xylia dolabriformis* in the Pegu Yoma forests proceeding from north to south.

Western side of watershed.

Sound trees 3 ft. and over in girth. No. per 100 acres.	Sound trees 3 ft. and over in girth. Percentage of total growing stock.	Forest or working circle.	Approximate rainfall. in.	Forest division.
		Satsuwa	..	Thayetmyo
228	13	Tindaw	45	
		E. Yoma	..	
280	17·9	N. Nawin	..	Prome
324	18·6	Middle Nawin	50	
248	17·3	S. Nawin	..	
300	17·5	Chaungzauk	..	
(158[1]	9·1[1])	Shwele	..	
284[2]	18·2	Taungnyo	55	Zigôn
308[2]		Bawbin	60	
190[2]		Gamôn	65	
230[2]		Minhla	70	Tharrawaddy
270[2]		Môkka	..	
211[2]		Kadinbilin	75	
250[2]		Kônbilin	80	
219[2]		Thonzè	..	
248	15·6	Rangoon hills	95	Insein

Eastern side of watershed.

Forest division.	Approximate rainfall. in.	Forest or working circle.	Sound trees 3 ft. and over in girth. Percentage of total growing stock.	Sound trees 3 ft. and over in girth. No. per 100 acres.
Pyinmana	40	Sinthè	9·5	205
	45	Taungnyo	12·7	190
	50	Pozaungdaung	12·2	275
	55	Ngalaik	16·6	294
	..	Yanaungmyin		
	60	Kaing	14·9	220
	..	Palwè		
	65	Yônbin	21·5	394
	70	Minbyin	15·5	330
	..	Yeni	14·1	360
N. and S. Toungoo	75	Saing Yane	17·1	317
	80	Kyaukmasin	16·7	317
	..	W. Swa		
	..	Sabyin	23·6	342
	85	Lonyan		
	..	Kabaung	23·3	328
	..	Bondaung	22·0	434
	90–100	Pyuchaung and Pyukun	21·9	385
Nyaunglebin	110–120	Nyaunglebin	27·6	505
Pegu	120	S. Zamayi	20·0	367

[1] These figures do not afford a fair comparison, as they are calculated on a total containing a considerable area of unproductive forest.

[2] The working plans give numbers of trees 1 ft. in diameter and over; the number 3 ft. in girth and over would be slightly greater.

FIG. 155. *Xylia dolabriformis* (with man at base) in upper mixed forest, Burma: large wound at base of tree caused by fire. Straight smooth-stemmed tree on left is *Homalium tomentosum*.

FIG. 156. *Xylia dolabriformis* seedling towards end of second season, regularly weeded and watered, height 6 ft. 3 in.

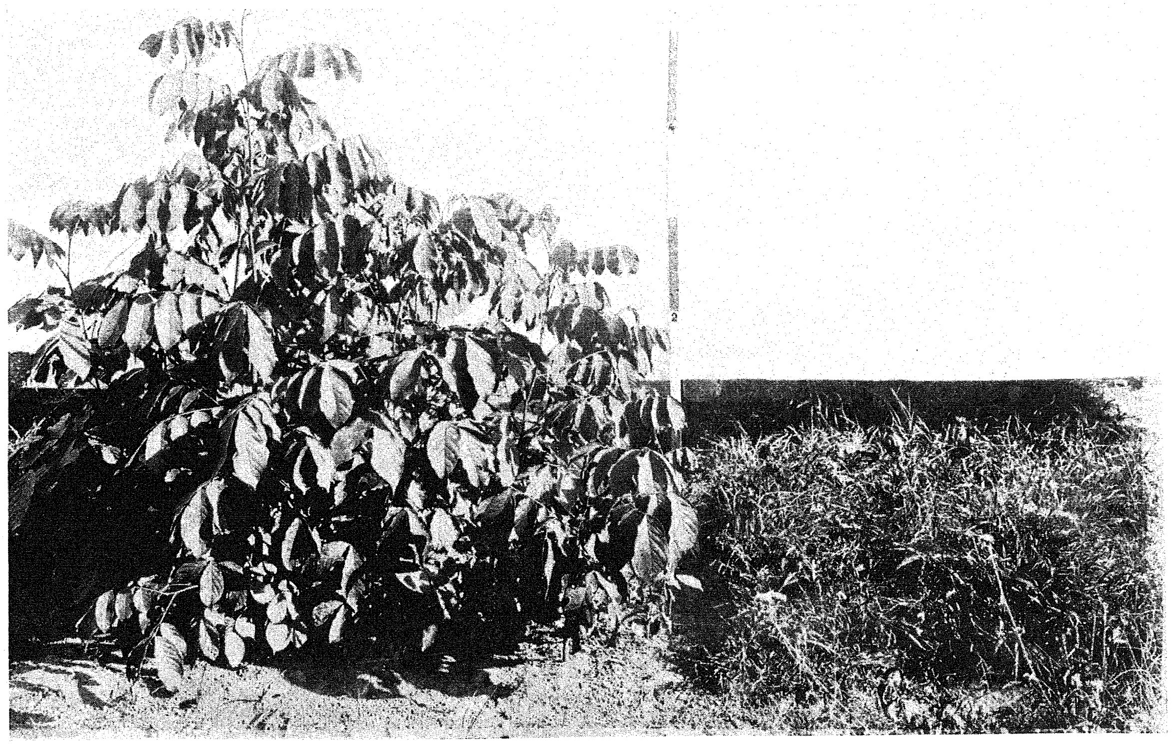

FIG. 157. *Xylia dolabriformis*, seedlings 15 months old, showing effect of weeding, Dehra Dun: plot to right of staff sown at same time but left unweeded. Staff shows feet.

Adjacent.

Adjacent.

The growth of the seedling during the first season is only moderate, a height of 5–12 in. being ordinarily attained. In the second and subsequent years, however, the development under favourable conditions is rapid, as the measurements in the statement below will show. Growth is greatly stimulated by regular weeding and loosening of the soil, as well as by moderate watering: it is much impeded by weeds and by stiff soil, as the seedling requires good drainage and soil-aeration.

Fig. 156 shows a plant towards the end of the second season, vigorous growth having been stimulated by regular weeding and watering.

A long taproot is developed at an early age; it may reach a length of 1 ft. in two months from germination and a length of 1·5 ft. or more by the end of the first season. In the middle of the second season a plant was dug up with a taproot 3 ft. 2 in. long and 0·6 in. in diameter. The seedling stands comparatively heavy shade in its early stages. It is sensitive to drought as well as to frost.

The table below gives a summary of measurements in experimental plots at Dehra Dun, in which the beneficial effects of weeding are clearly demonstrated. The rate of growth for a locality far outside the natural habitat of the species is remarkable.

Xylia dolabriformis: rate of growth of young plants, Dehra Dun.

Condition under which grown.	Height at end of season.			
	1st season.	2nd season.	3rd season.	4th season.
(1) In nursery, weeded and watered	0 ft. 3 in.–0 ft. 6 in.	..	..	..
(2) In nursery, weeded and watered	0 ft. 4 in.–0 ft. 11 in.	Maximum 3 ft. 9 in.	..	..
(3) In nursery, weeded and watered	Maximum 0 ft. 11 in.	6 ft. 3 in. (one plant)	11 ft. 4 in. (girth 6 in.)	17 ft. 4 in. (girth 10 in.)
(4) Broadcast sowing (seed lightly covered), irrigated, weeded	Maximum 0 ft. 7 in.	0 ft. 8½ in.–4 ft. 0 in.	..	..
(5) Broadcast sowing (seed lightly covered), irrigated, not weeded	Maximum 0 ft. 6 in.	0 ft. 4 in.–1 ft. 5 in. (impeded by weeds)	..	..
(6) Broadcast sowing (seed lightly covered), unirrigated, weeded	Maximum 0 ft. 9 in.	0 ft. 9 in.–5 ft. 1 in.	—	12 ft. 6 in. (girth 6 in. at 4 ft. from ground)
(7) Broadcast sowing (seed lightly covered), unirrigated, not weeded	Maximum 0 ft. 6 in.	0 ft. 3 in.–0 ft. 11 in. (impeded by weeds)	..	..
(8) Natural conditions (seed scattered on surface of ground), not weeded after sowing—in open	Maximum 0 ft. 5 in.	All killed by drought	..	..
(9) Natural conditions (seed scattered on surface of ground), not weeded after sowing—in open	0 ft. 2 in.–0 ft. 5 in. (impeded by weeds)	..	..	..
(10) Natural conditions (seed scattered on surface of ground), not weeded after sowing—in slight shade	0 ft. 3 in.–0 ft. 5 in.	..	..	..
(11) Natural conditions (seed scattered on surface of ground), not weeded after sowing—in heavy shade	0 ft. 3 in.–0 ft. 7 in.	..	..	..

Fig. 157 shows in a striking manner the effect of regular weeding. A plot was sown broadcast: no watering was done, but the portion to the left of the staff was regularly weeded, the soil being kept loose, while the portion to the right of it was left unweeded. The effect of the weeding after fifteen months is very marked.

Silvicultural characters. The tree is a shade-bearer, particularly in youth, although in this respect it cannot compete with the more shade-bearing evergreens. It is sensitive to drought in youth. For its best development it requires a moist, deep, well-drained soil; it is sometimes found on dry shallow soils, where, however, it never reaches large dimensions. Owing to its thin bark it is readily injured by fire, large wounds due to this cause being frequently found at the base of the tree, as shown in Fig. 155. The tree is attacked by a parasitic fungus, *Fomes fulvus*, Fries, the spores of which probably gain admission through wounds (see *Indian Forester*, xxvi. 19 and 160). The tree coppices well up to a moderate size: it is not known if it produces root-suckers like the Indian species.

Natural reproduction. Experiments at Dehra Dun gave the following results: (1) Germination takes place very readily at the commencement of the rainy season. (2) Bare ground favours germination, but if the ground is hard the germinating seedling is liable to dry up before the radicle penetrates the soil; loosening the soil greatly helps matters. (3) Mortality also takes place during germination owing to (*a*) the rotting of the radicle or the seed in heavy wet weed-growth or on badly-drained ground, (*b*) the destruction of the radicle by birds and insects, (*c*) the drying up of the radicle or the swollen seed if exposed to the sun after germination has started; this is a very fruitful cause of death. (4) Under shade (other than that of heavy wet weed-growth) germination takes place readily, and the seedling can establish itself without difficulty; in shady places the radicle may creep along the ground for some distance before it gains admission to the soil, and even roots and leaves may form before the seedling gains a footing, which would be impossible in the sun.

These results appear to indicate that natural reproduction is favoured by *loose bare ground under shade where the drainage is good.* The question of light necessary for its establishment is considered below.

In the forest young pyinkado seedlings are often found in large quantities under these conditions. On the surface of a new road under construction through the Kônbilin forest in Tharrawaddy, where the soil had recently been dug up and levelled, in June 1904 I observed seedlings in countless numbers; these were so numerous that it was impossible to walk without treading on them at every step. In the same forest pyinkado seedlings have frequently been observed in quantity under the shade of teak plantations of different ages.

The effect of fire-protection on the natural reproduction of pyinkado is often most pronounced, and annual reports frequently contain references to the quantity of seedlings appearing in fire-protected forests. It is an undoubted fact that in the moister types of deciduous teak-bearing forest in the Pegu Yoma teak is to a large extent being replaced by pyinkado under the influence of fire-protection, which, while greatly assisting the reproduction of pyinkado, has a correspondingly adverse effect on that of teak. The stimulus given by fire-protection to pyinkado reproduction has been observed in moist and dry upper mixed forest, both with and without bamboos, as well as in lower mixed forest. On the other hand, cases of good reproduction in areas annually burnt may also be observed, though such cases occur only where the state of the soil-covering is such as to preclude severe fires. The effect of

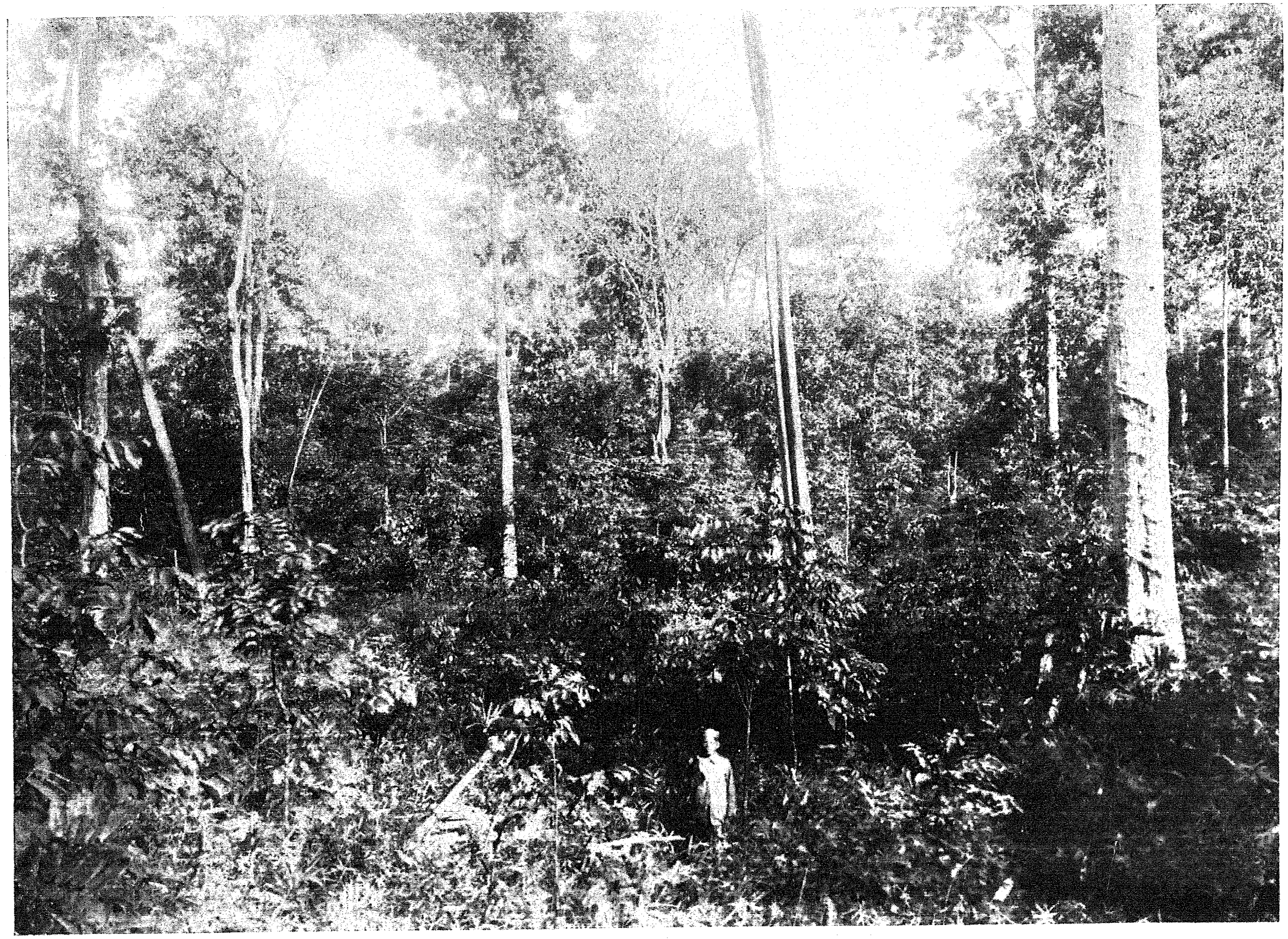

Fig. 158. *Xylia dolabriformis*, dense natural reproduction in fire-protected forest, establishment assisted by gradual opening of the overhead canopy combined with repeated cleanings, overwood consisting of teak and other trees ready for removal, Minhla reserve, Tharrawaddy, Burma.

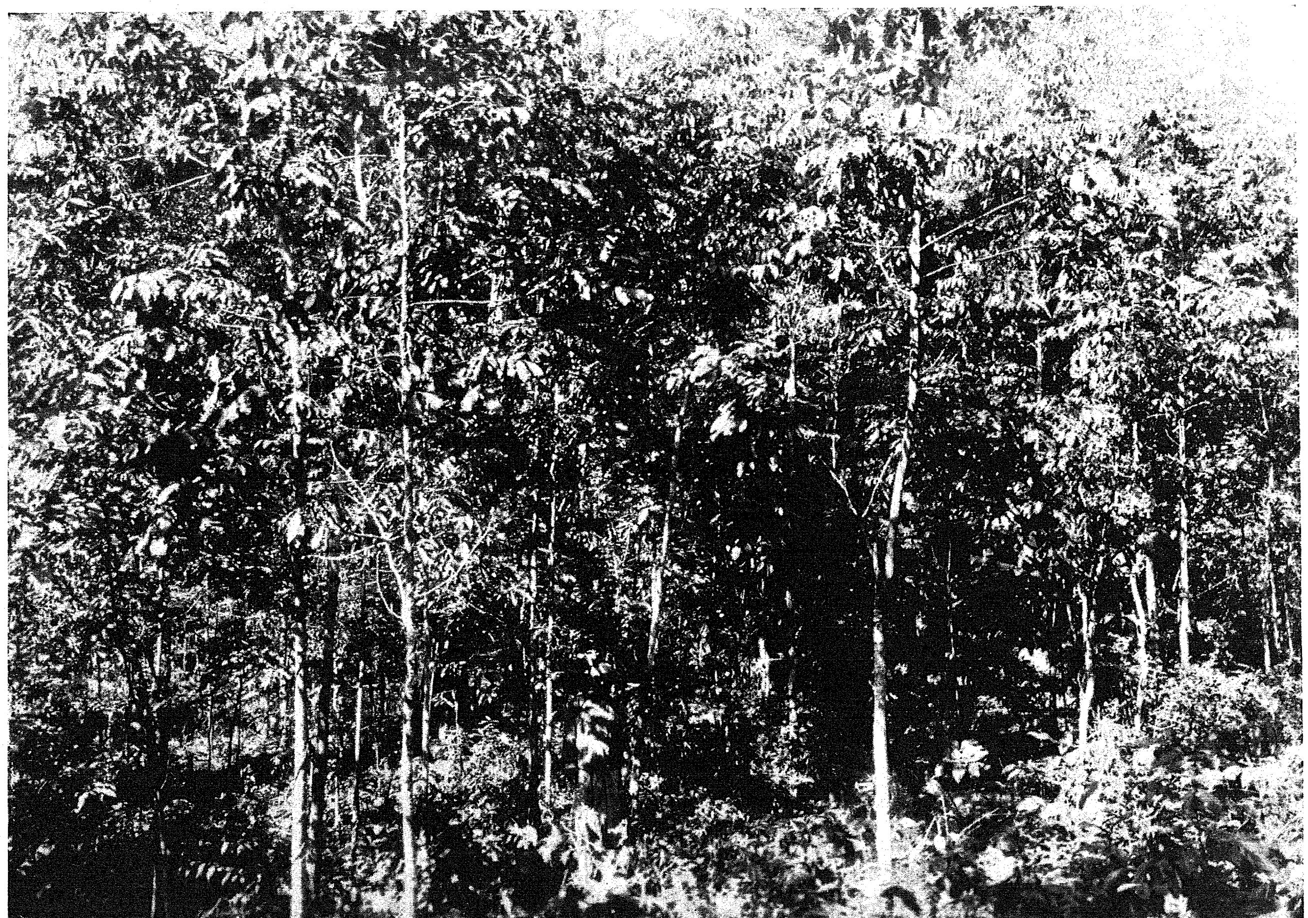

FIG. 159. *Xylia dolabriformis*, dense natural sapling crop in fire-protected forest, assisted by gradual opening of overhead canopy combined with repeated cleanings, Kônbilin reserve, Tharrawaddy, Burma.

fire-protection, however, does not appear to be universally beneficial, for cases are recorded, particularly from South Tenasserim, where owing to the thick carpet of leaves, and possibly owing sometimes to the dense undergrowth, the seedlings fail to establish themselves in fire-protected forest. This appears to indicate that, as in the case of teak, when the type of forest passes a certain degree of moisture protection induces conditions adverse to successful reproduction; this degree is passed at a considerably drier stage in the case of teak than in the case of pyinkado.

Another factor of great importance to the establishment of pyinkado reproduction is light. Although seedlings appear under fairly heavy shade and may even persist for a time, they become suppressed and killed out unless a moderate amount of light is admitted. Operations carried out in Tharrawaddy to assist natural reproduction have shown, however, that if the overhead cover is opened out severely a heavy growth of grass and weeds tends to spring up in which pyinkado seedlings, though they may appear in large numbers, become suppressed, while, on the other hand, if the cover is removed gradually weeds are prevented from coming in to the same extent and the advance growth of pyinkado grows rapidly: repeated weeding and cleaning in the earlier years is necessary, however, in order to bring up the young crop. Figs. 158 and 159 illustrate the manner in which natural young crops of pyinkado can be established in fire-protected forest by the gradual opening of the canopy combined with weedings and cleanings. Observations have been recorded in various localities regarding the quantity of reproduction which springs up in areas where felling and bamboo cutting have taken place, the disturbance of the soil no doubt assisting as well as the admission of light.

Mr. T. W. Forster,[1] writing of the effect of the admission of light on the reproduction of pyinkado in Tharrawaddy, notes that whereas young pyinkado is well distributed over areas where bamboos are absent, it is conspicuous by its absence in many bamboo areas except along the outer edges where side light has penetrated and in places where clumps have died after seeding. That seedlings do appear in large quantities in untreated bamboo areas may be realized from the following countings made in two plots: (1) area $\frac{1}{4}$ acre: seedlings present, 3,309, or 13,200 per acre; (2) area 1 square chain: seedlings present, 1,088, or 10,800 per acre. In such cases, however, if sufficient light is not admitted a very large proportion of these die off. The following countings on a linear survey 9 chains in length covering 1·8 acres in untreated bamboo forest in the Môkka reserve show the extent to which the establishment of seedlings and saplings is prevented by the effect of overhead cover:

Seedlings 1 ft. in height and over	3,691
Poles 8 in.–1 ft. in girth	21
Trees 4–5 ft. in girth	2
Trees 5–6 ft. in girth	2
Trees over 6 ft. in girth	2

Within recent years special attention has been paid in some of the Pegu Yoma tracts to the question of obtaining natural reproduction of pyinkado. It has been demonstrated clearly that once their roots have become well established young pyinkado plants are capable of surviving severe burning almost as well as teak, and although burnt back they afterwards send up strong

[1] Ind. Forester, xxxviii (1912), p. 455.

vigorous shoots. This takes place even after severe fires in flowered bamboo areas. Experiments in Prome, Tharrawaddy, and Toungoo have shown that natural reproduction can be secured in quantity by cutting bamboos and other growth in the vicinity of seed-bearers, in order to lighten the cover, and thoroughly burning the cut material. Natural pyinkado seedlings appear in quantity on the burnt ground; thereafter the area is fire-protected and the young crop is regularly weeded, while light is admitted gradually by the removal of the overwood. This results in the establishment of dense young crops of pyinkado.

The immunity of well-established pyinkado seedlings from destruction by fire indicates the treatment which would probably be successful in mixed teak and pyinkado crops. This would consist of encouraging pyinkado advance growth by a slight opening of the canopy near seed-bearers, accompanied by burning; for some years the area would be fire-protected and the young pyinkado would be weeded if necessary until well established. A clear felling and burning of the area would then secure teak reproduction, while the young pyinkado, after being burnt back, would shoot up again from the base. Further weeding of the young mixed crop would then be necessary until it is established. It may be noted in this connexion that pyinkado reproduction often appears in teak *taungya* plantations in the form not only of seedlings but also of coppice-shoots from the bases of saplings which have been burnt back.

Natural reproduction of pyinkado is sometimes found in great quantity in the rather dry type of forest known as *thitkyin* alluded to above, containing few or no bamboos; this reproduction is the result of fire-protection, but the young plants are kept in suppression, and few succeed in making their way up unless the canopy is opened.

Artificial reproduction. Experiments at Dehra Dun have shown that direct sowing gives much greater success than transplanting from the nursery. Transplanting, if carried out carefully in rainy weather, was found to be successful with small plants in the first rainy season, but not with large plants in subsequent years. Pruning down the stem and the root did not prove successful, either in the first year or subsequently.

The beneficial effects of thorough weeding and loosening of the soil have already been alluded to under 'the seedling', and hence line sowings, where these can be carried out most effectively, are indicated as likely to give the best results.

In the Kyangin reserve of the Henzada forest division a mixture of teak and pyinkado has been tried with field crops in shifting cultivation (*taungya*) on a fairly extensive scale, but owing to the different requirements of the two species as regards germination the success has not been great. Teak seed, in order to germinate successfully, requires to be put in early in order to obtain the benefit of the alternating showers and hot sun at the commencement of the rainy season. Pyinkado seed, on the other hand, germinates with the first shower, and in an open *taungya* the germinating seedling is dried up on the next sunny day. To sow the pyinkado later when the rains have well set in would add to the cost of the plantation, and might be difficult in practice. A small *taungya* plantation of pure pyinkado was formed in the Tharrawaddy division about 1900. This I saw in 1904, and the plants were few in number

and in poor condition: the surrounding forest contained pyinkado trees of good quality, and the poor condition of the plantation, in which the ground was covered with a thick growth of grass, was probably due to this growth of grass, to unfavourable soil conditions induced by the removal of the forest cover, and to the exposure of the plants to the sun. The readiness with which natural reproduction of pyinkado sometimes springs up in teak plantations would indicate that it might be introduced successfully as an under-story in such plantations if the correct degree of light is obtained: sowings of pyinkado in lines between the lines of teak, after the latter have been sufficiently thinned out, should not be difficult to carry out.

2. **Xylia xylocarpa** (Roxb.), Hole in *Ind. For.*, xxxviii. 463. Vern. *Jamba, yerul, suria*, Mar.; *Jambe, tiruwa*, Kan.; *Irul*, Tam.; *Tangedu*, Tel.; *Irumulla, kada*, Mal.

A moderate-sized to large deciduous tree. Leaves bipinnate with one pair of pinnae, each pinna with two to six pairs of leaflets. Bark 0·2–0·5 in. thick, smooth, reddish grey, exfoliating in large irregular plates. Wood very hard, reddish brown, durable, liable to split in seasoning, used for house and bridge construction.

The tree is considerably smaller than the Burmese species, seldom reaching a height of more than 60 ft. and a girth of more than 6 ft.; in dry localities and on poor ground it attains much smaller dimensions than these, and produces a somewhat crooked and fluted bole.

Distribution and habitat. This tree occurs in the Indian Peninsula, extending as far north as Bombay in the west, Orissa in the east, and the Balaghat district of the Central Provinces in the centre. It extends southward to Travancore, but is absent from the south of that state. It is not found in the dry districts of the Deccan. It is plentiful throughout the deciduous forests of the Western Ghats, in the Belgaum and North Kanara districts of Bombay, and in South Canara, Malabar, and thence south to Travancore. Here its most important companions are teak, *Terminalia tomentosa*, *T. paniculata*, *Lagerstroemia lanceolata*, *Dalbergia latifolia*, *Pterocarpus Marsupium*, *Adina cordifolia*, and *Schleichera trijuga*. It is, however, a typically gregarious tree, often forming nearly pure crops, especially on abandoned cultivation. In the east of the Peninsula it is plentiful in some of the deciduous forests of the Godavari district, where it also becomes more or less gregarious. It is locally common in Ganjam. In the Puri district of Bihar and Orissa it occurs on low hilly country, where it is sometimes mixed with sal, forming pole crops. In the Central Provinces it is found locally in mixed deciduous forests on hill slopes and in valleys in Chanda, Bhandara, Balaghat, Raipur, and Nagpur, sometimes forming dense pure young crops under teak and other species.

The tree is found on various geological formations, such as granite, gneiss, mica schist, basalt, trap, quartzite, sandstone, and limestone, while it is sometimes very plentiful on laterite, though on this formation it does not appear to attain large dimensions.

In its natural habitat the absolute maximum shade temperature varies from 95° to 115° F., the absolute minimum from 37° to 62° F., and the normal rainfall from 50 to 180 in. or perhaps more.

Leaf-shedding, flowering, and fruiting. The leaves fall about

February and the new leaves appear in March or April, the flowers appearing at the same time. The globose fragrant flower-heads are yellowish white, 0·5–0·7 in. in diameter, with numerous very small flowers. The pods commence ripening next December, and the seed as a rule all falls by March. The pods are brown, 4–6 in. long by 2–2·5 in. broad, flat, woody, falcate-oblong, containing six to ten seeds. The pods dehisce on the tree, the hard woody valves bursting open elastically, curving backwards and ejecting the seeds. The open pods do not remain long on the tree, and have usually all fallen by the end of May; the hard valves may then be found in quantity on the ground. The seeds (Fig. 160, *a*) are flat, ovate, oblong or nearly orbicular, 0·5–0·7 in. by 0·35–0·5 in., brown, smooth, shining, with a moderately hard testa.

GERMINATION (Fig. 160, *b–d*). Epigeous. The testa splits at one end and the radicle emerges and descends rapidly. The hypocotyl arches and elongates, soon straightening and raising the cotyledons above ground. The testa is usually carried up over the cotyledons, falling to the ground with their expansion.

THE SEEDLING (Fig. 160).

Roots: primary root long, moderately thick, terete, tapering, wiry, glabrous or minutely pubescent when young: lateral roots fairly numerous, at first short, afterwards long, fibrous, distributed down main root. *Hypocotyl* distinct from the root, 1·5–2·5 in. long, fusiform or tapering slightly at the lower end, white turning green, minutely pubescent. *Cotyledons*: petiole 0·05 in. long, thick: lamina 0·7–0·9 in. by 0·5–0·6 in., broadly elliptical or obovate, apex rounded, base sagittate, entire, fleshy, glabrous, upper surface flat or slightly concave, lower surface convex, veins not distinct. *Stem* erect, woody, green turning brown, young parts pubescent; internodes 0·3–1·2 in. long. *Leaves* compound, first pair opposite, paripinnate, with two pairs of leaflets, subsequent leaves alternate with 1, 2, or 3 pairs of leaflets, very rarely trifoliate; bi-compound leaves, with leaflets up to six pairs, are ordinarily produced in the second season. Stipules up to 0·2 in. long, linear lanceolate, acuminate, pubescent. Rachis (first season) 0·8–5 in. long, pubescent, terminating in a fine bristle. Leaflets opposite, with petiolules up to 0·1 in. long, 0·7–5 in. by 0·25–2 in., ovate or ovate lanceolate, acuminate, entire, glabrous above, pubescent on the veins beneath, terminal pair larger than remaining leaflets, young leaves often copper-coloured.

Nursery-raised seedlings in Malabar reach a height up to 1 ft. in the first season, and between 2 and 3 ft. by the end of the second season.

The seedling stands a good deal of shade when young, though when once established it benefits by the admission of light. Experience gained in sowings in Coorg shows that it is sensitive to drought. A long taproot is developed early, and may attain a length of 1 ft. or more within a month of germination. As in the case of the Burmese species, the growth of the seedling is greatly stimulated by weeding. The young plants are not eaten by cattle.

SILVICULTURAL CHARACTERS. The tree is a shade-bearer, particularly in youth: it owes its gregariousness in part to this character, which enables it to gain a footing under the moderate shade of mixed deciduous forest, though it cannot compete with the heavy shade-bearers of the evergreen forests. Although it grows best on deep soil overlying sandstone and crystalline rocks it is usually more gregarious on shallow soil on laterite, though here it does

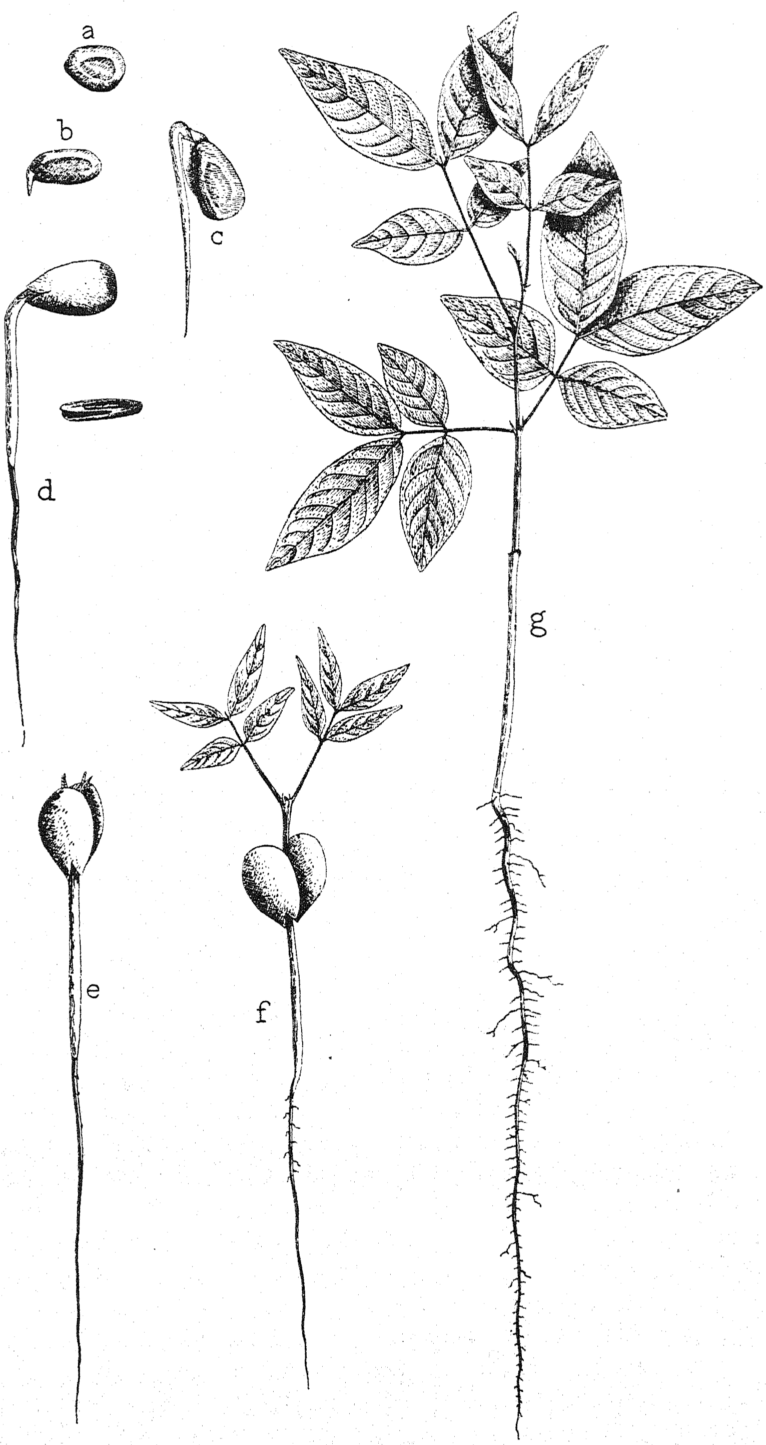

FIG. 160. *Xylia xylocarpa.* Seedling × $\frac{1}{3}$.
a, seed ; *b–d*, germination stages ; *e–g*, development of seedling during first month.

not attain large dimensions. Bourdillon notes that in Travancore it does not seem to thrive well at the lower elevations where it is most common, but is badly shaped, fluted, and twisted, whereas at 1,500 ft. and upwards, where it is not so abundant, it attains a larger size: this may, however, possibly be due to geological formation and soil rather than to elevation. Opinions appear to vary as regards the fire-resisting power of this tree. Talbot attributes the defective unsound stems in the Bombay Presidency to forest fires: Mr. D. T. Barry,[1] writing of South Canara, says it withstands fire better than most species. The effect of fire on natural reproduction is dealt with below.

The tree coppices and pollards well, and produces root-suckers in abundance, particularly in burnt areas and where the roots are exposed. Coppice and pollard experiments carried out in 1909 in North Chanda, in which cutting was done in April, May, and June, gave the following results in the case of *Xylia* as compared with teak:

(1) Percentage of stools which produced coppice-shoots: *Xylia* 95 per cent.; teak 97 per cent.
(2) Percentage of success in pollarding: *Xylia* 85 per cent.; teak 73 per cent.

Natural reproduction. The seeds germinate with the early showers of the rainy season, and in May numerous young seedlings may be found on the ground with the cotyledons still present. The natural reproduction of this tree is profuse throughout the greater part of its habitat, and in Bombay it threatens in places to oust more valuable species such as teak, blackwood, and *Pterocarpus Marsupium*, forming pure young crops under the other trees of the mixed deciduous forests, often to the almost complete exclusion of other species. In the teak plantations of Nilambur in South Malabar young crops of *Xylia* have appeared in quantity on the laterite areas where the teak develops poorly and has almost disappeared in places. In the Central Provinces natural reproduction has spread extensively in the mixed deciduous forests where seed-bearers are present, forming dense pure crops under teak and other trees, and it is a question whether the tree will not yet prove to be noxious in preventing the reproduction of the more valuable species. In the majority of cases the spread of *Xylia* reproduction is directly traceable to fire-protection, its shade-bearing character and its immunity from damage by grazing being of special assistance to it. In moist regions where the vegetation tends to assume a tropical evergreen character, however, fire-protection appears to have the reverse effect, favouring the spread of the more shade-bearing evergreens, to the detriment of *Xylia* reproduction.

Natural reproduction springs up with great freedom on abandoned fields during the process of shifting cultivation, the sites of former cultivation being often marked by pure patches of *Xylia*. This indicates its partiality for new soil, which favours the germination of the seed and the establishment of the seedling, as in the case of the Burmese species, and its capacity for contending successfully against the second-growth species which appear on abandoned cultivation.

Artificial reproduction. Little appears to have been done so far to

[1] Ind. Forester, xxxix (1913), p. 30.

form plantations of this species, since its natural reproduction is as a rule so good. It has been raised experimentally in Coorg with the aid of shifting cultivation (*kumri*), but the seedlings were found to suffer to some extent from drought. Possibly it requires to be grown under moderate shade for a time.

SILVICULTURAL TREATMENT. Hitherto the tree has been worked along with the other species associated with it either in some form of selection fellings or as coppice-with-standards. For the latter system it is suitable. The ease with which natural reproduction can be secured, and the tendency of the tree to form even-aged pure crops, indicate that there should be little difficulty in treating it by concentrated high forest regeneration fellings with the object of producing even-aged crops. It could also be employed usefully to form an under-story to other species of greater value, whether in plantations or in natural crops.

RATE OF GROWTH. (1) *Natural high forest.* The annual rings, though more or less visible, are not very distinct. Certain working plans in the North Kanara district of Bombay estimate the rate of growth by ring-countings. The following statement, prepared after reducing the figures to girth measurements, obtaining average curves after plotting by rectangular co-ordinates, and including bark thickness, gives a summary of the results :

Xylia xylocarpa : rate of growth in girth in high forest, North Kanara district, Bombay.

Age.	Supa fuel reserves.[1] (1906)		Ankola high forest, Blocks xxiv and xxv.[2] (1908)		Kalinaddi slopes, Block xxvi.[2] (1909)		Sopinhosalli high forest, Block xxvii.[3] (1910)		Ankola-Kumta coast.[3] (1911)		Sirsi town forests.[3] (1913)		Yekambi-Sonda high forest, Block xxviii.[3] (1914)	
years.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
10	0	6	0	6	0	7	0	7	0	6	0	4	0	3
20	1	0	1	0	1	2	1	0	1	0	0	9	0	7
30	1	5	1	5	1	6	1	5	1	5	1	1	1	1
40	1	10	1	10	2	0	1	9	2	0	1	6	1	7
50	2	4	2	3	2	6	2	2	2	5	1	10	2	1
60	..		2	8	2	11	2	7	2	11	2	2	2	7
70	..		3	1	3	5	3	0	..		2	7	3	0
80	..		3	6	3	10	3	5	..		2	11	3	5
90	..		3	11	4	4	3	9	..		3	3	3	10
100	..		4	3	4	10	4	2	..		3	8	4	3
110	..		4	6	5	3	4	7	..		4	0	4	7
120	..		4	10	5	8	5	0	..		4	3	5	0
130	..		5	1	5	11	5	5	..		4	7	5	4
140	..		5	4	6	2	5	9	..		5	10	5	8
150	..		5	7	6	4	6	2	..		5	2	6	0
160	..		5	10	6	5	6	7	..		5	5	6	3
170	..		6	0	..		..		..		..		6	6

[1] Measurements by D. A. Thomson. [2] Measurements by R. S. Pearson.
[3] Measurements by P. E. Aitchison.

(2) *Planted trees.* Bourdillon says measurements of trees planted at Malayattur in Travancore showed the following growth :

Age 5 years, height 25 ft., girth 10 in.
,, 10 ,, ,, 60 ft., ,, 22 in.

Under favourable conditions, therefore, it appears that the tree is capable of very rapid growth.

(3) *Coppice.* Measurements in coppice coupes in the Karwar fuel reserves, West Kanara forest division, Bombay, gave the following results from the average curve after plotting :[1]

Age in years.	Mean girth at breast height. ft.	in.
5	0	6
10	0	9·5
15	1	0·2
20	1	2·3

Measurements in 1912–13 of coppice-shoots one year old in the Bhandara forest division, Central Provinces, showed an average height of 6 ft. 8 in. for *Xylia* as against 7 ft. 1 in. for teak. Measurements by Mr. H. Gass in 1898–9 in coppice coupes in Kadike block, South Canara district, Madras, gave the following results :[2]

Xylia xylocarpa : coppice measurements, South Canara.

	Girth.		Height.		Number of shoots per stool.
Age.	Mean.	Maximum.	Mean.	Maximum.	
years.	in.	in.	ft.	ft.	
2	—	—	16	20	1 to 20, average 10
3	6·6	10	15	20	

3. ACACIA, Willd.

This important genus contains over twenty Indian species as well as some introduced species, the three most important of the latter being the Australian trees *A. decurrens*, *A. dealbata*, and *A. Melanoxylon.* The Indian acacias are essentially xerophilous, occupying for the most part the dry and arid regions where the forests are often of the nature of open thorny scrub : some of the species assume the spreading flat umbrella-like crowns characteristic of open xerophilous woodland in the tropics, for example *A. planifrons*, *A. Latronum*, and *A. leucophloea.* The Indian tree species are essentially light-demanding, regenerating on open ground and being intolerant of suppression. Some species reproduce most freely on recent riverain alluvium, notably *Acacia Catechu* and *A. arabica* ; *A. Farnesiana*, an introduced species, also runs wild gregariously in river-beds. Some species have indehiscent or tardily dehiscent pods, e.g. *A. arabica*, *A. modesta*, *A. Senegal* ; others have dehiscent pods, e.g. *A. Catechu*, *A. Latronum.* The seeds of acacias as a rule retain their vitality for a considerable time. Germination is epigeous in all the species examined.

Some species coppice well, for instance *A. Catechu*, *A. modesta*, *A. leucophloea*, *A. dealbata*, *A. decurrens* ; others coppice with less freedom, and in some localities hardly at all, for example *A. arabica* and *A. Melanoxylon.*

Root-suckers are probably produced on occasion by most if not all species ; even *A. arabica*, which does not ordinarily produce suckers, does so occasionally, while *A. Catechu* does so sometimes when the roots are exposed.

[1] Working Plan for the Karwar Fuel Reserves, West Kanara Division, Bombay, D. A. Thomson, 1904.

[2] Inspection note, 1899.

Suckers are produced more freely by *A. planifrons* and *A. leucophloea*, and in profusion by *A. dealbata* and *A. decurrens*.

Species 1. *A. arabica*, Willd.; 2. *A. leucophloea*, Willd.; 3. *A. Catechu*, Willd.; 4. *A. modesta*, Wall.; 5. *A. Senegal*, Willd.; 6. *A. planifrons*, W. and A.; 7. *A. Latronum*, Willd.; 8. *A. Farnesiana*, Willd.; 9. *A. eburnea*, Willd.; 10. Australian acacias: (1) *A. decurrens*, Willd., (2) *A. dealbata*, Link, (3) *A. Melanoxylon*, R.Br.

1. **Acacia arabica**, Willd. Syn. *Mimosa arabica*, Lam. Babul. Vern. *Babul*, Hind.; *Kikar*, Pb.; *Babar*, Sind; *Jali*, Kan.; *Nella tuma*, Tel.; *Karu velam*, Tam.

A moderate-sized almost evergreen tree with a short trunk, a spreading crown, and feathery foliage. Bark dark brown, nearly black, pinkish brown and hard inside, with regular deep longitudinal fissures which very often run spirally up the tree. Young branches green, pubescent. Stipular spines straight, white, up to 2 in. long, variable, sometimes absent in old trees.

The tree varies much in size, remaining little more than a shrub in some localities, and in others attaining a height of 50 to 60 ft. or even more, and occasionally a girth of 8 to 10 ft. Brandis says the largest girth recorded is 16½ ft. near Multan.

Acacia arabica is probably the most important tree in the drier parts of India. The sapwood is whitish and large: the heartwood is pink, turning reddish brown on exposure, hard and very durable if well seasoned. The wood is used for building, carts and carriages, wheel-work, agricultural implements, boat-building, and many other purposes, and is an excellent fuel. The bark is extensively used for tanning. The pods are rich in tannin, and are also largely used as fodder for cattle, goats, and sheep. The leaves and twigs are used as fodder and the thorny branches as fencing material. The bark exudes a gum largely used in dyeing and calico-printing and for native medicine. Lac is grown on the tree in Sind. In the dry hot regions in which it grows it is a useful shade tree with its spreading evergreen crown, and although its shade is somewhat light it is frequently grown on camping grounds and along roadsides.

Varieties. Several varieties of *Acacia arabica* have been distinguished. There are three ordinarily recognized varieties in India, which come true to seed: these are—(1) The typical *A. arabica* with spreading shady crown and moniliform pods. This is the *godi*, *teli*, or *telia babul*, the wood of which is much prized: this variety is the one of most importance economically, and the one extensively grown in plantations or natural forest crops. (2) Var. *vediana*, the *vedi*, *kavadi*, *kaora*, *kaulia*, or *kauria babul*. As compared with the typical or *telia* variety this one is smaller, with a shorter bole, the bark is rougher and more fissured, with more pronounced exfoliation, the pods are flat and little constricted between the seeds and are on shorter stalks, the spines are more numerous, stouter and whiter and up to 2½ in. long, the crown is more spreading, while the branches are more twisted and interlacing. The wood of the *kauria babul* is inferior to that of the *telia*, and is usually considered fit only for firewood, though in cases of necessity it is used as timber, particularly for agricultural implements: hence this variety is cut or weeded out wherever possible in favour of the *telia*. This variety, which is common

in the Deccan, appears to be a xerophytic form of the typical variety. (3) Var. *cupressiformis*, the *ramkanta* or *ramkati babul* or *kabuli kikar*. This variety is recognized by its broom-like (cupressiform) ascending branches: the stem is tall and the branches are thin. It is found in parts of the Punjab, Sind, Rajputana, and the Deccan, where it is fairly common in the Poona district. In Berar there is a religious prejudice against using its timber. The word *ramkati* signifies Rama's *kati* or wand.

The present account of this tree will relate to the *telia* or typical variety unless the contrary is stated, since this is the important variety for forest purposes.

Distribution and habitat. *General distribution*. *Acacia arabica* is probably indigenous in Sind, Rajputana, Guzerat, and the northern Deccan; it is cultivated or self-sown throughout most of the drier parts of India, but not in the extreme north-west of the Punjab, where the winter cold is too severe. It is not found in the moister regions. It has been introduced into parts of the dry zone of Upper Burma and has spread to some extent. It is essentially a tree of the plains, occurring on flat or gently undulating ground and ravine country, but not extending into hilly regions. The tree is found also in Africa and Arabia.

Climate. The babul is characteristic of dry regions, but will not thrive without irrigation if the climate is too arid. In regions where it is indigenous or has become naturalized the absolute maximum shade temperature varies from 105° to 122° F., the absolute minimum from 30° to 60° F., and the normal rainfall from 3 to 50 in. In regions of low rainfall such as Sind, however, the existence of the tree is rendered possible only by river inundations: otherwise it is doubtful if the babul is capable of flourishing with a rainfall of less than 20 in., in which connexion Talbot remarks:[1] 'Quite recently a very large area (over 50,000 acres) of reserved forest in the Poona district, where laborious efforts had been made over a long series of years to raise *babul*, had to be disforested, as it was found that the rainfall was insufficient, even in good soil, to produce anything but small, stunted, and decaying stems of very little climatic or economic value.'

Soil. The two commonest types of soil on which the babul occurs are riverain alluvium subject to inundations and black cotton soil. The former is exemplified on a large scale in Sind and to a lesser extent along the rivers of the Deccan. Black cotton soil is common in many parts of the Peninsula and in the southern part of the Indo-Gangetic plain. It is a stiff soil which absorbs large quantities of water in the rainy season, becoming sodden like a sponge: in the dry season it dries and contracts, forming large deep cracks all over the surface of the ground, and it is only by sending its long taproot down into the moister subsoil beneath that the young plant is able to survive the dry season and establish itself.

Apart from the two classes of soil mentioned, however, the tree is also frequently found on other types of soil, for example over large stretches of country on alluvial loam in the plains of northern India, on loamy soil in the Peninsula, and in tank beds in the Madras Presidency. In any type of soil, however, it is essential that there should be a sufficient degree of permanent

[1] For. Flora Bombay, i. 482.

moisture in the soil and subsoil, for in this respect the babul is exacting. Shallow soils with underlying sheet rock or beds of *kankar* have a stunting effect: on such ground the *kauria* usually replaces the *telia* variety where both occur, and the same applies to saline soils. The capacity of the babul for existing on saline soils appears to depend on the presence of a considerable amount of moisture in the soil. In Sind it cannot exist for any length of time on saline soil, but here this soil denotes a failing water-supply, a condition which is unsuitable for the growth of the tree in the dry climate of Sind. In Berar, according to Mr. Shrinivasulu Nayadu,[1] 'the existence of soda salts to a large extent in the soil favours the growth of babul and its few associates to the exclusion of other trees.' Many of the saline tracts, however, are on the alluvium along the Purna river, where there is a considerable amount of moisture in the soil. That the babul can actually flourish in salt water, and that absence of soil moisture rather than salinity is probably the main reason for its failure to grow on dry saline soils, is indicated from the following quotation from the Madras Forest Report for 1909–10: 'The experiments conducted in Lower Godavari and Kistna for promoting babul growth on the saline soils have not been successful, but inspection showed precisely the defects. In Lower Godavari the area was blank; it was evident that the water ran off almost at once. In Kistna the area was on a slope, the upper part blank, the lower part and hollows filled with babul seedlings, some of which, only one or two years old, were 5 ft. or 6 ft. high. It is evident, then, that if the water can be retained for some time, until the roots reach moisture level, babul will succeed. Nor is fresh water necessary below, for babul was found flourishing with its roots in perfectly salt water creeks.' The same is observable along brackish creeks near Bombay, where the tree is seen in close proximity to mangrove species.

TYPE OF FOREST. *Acacia arabica* is a typically gregarious tree, forming crops which are pure or in which it is usually the most prevalent species. It is a strong light-demander, and the crops come up in even-aged groups or patches of varying extent. Forests of *Acacia arabica* are frequently termed babul *bans* and sometimes babul meadows, the latter term referring to the grassy undergrowth so prevalent in forests of this species. Its companions vary in different localities: these, together with its mode of occurrence, can best be dealt with for different localities separately.

Sind. Sind contains by far the most extensive babul tracts in India, the area of babul forest being roughly estimated at 172,000 acres, though this area is subject to constant change owing to river action. The babul tracts are situated on both banks of the river Indus. The distribution, and indeed the existence, of the babul in Sind is governed by this river and its effect on the soil moisture, for climatically Sind is unsuitable for the growth of babul. In the regions where the tree is found the absolute maximum shade temperature varies from 116° to 122° F., and the absolute minimum from 30° to 40° F., while the normal rainfall varies from 3 to 10 in. Under ordinary circumstances it would be impossible for the babul to exist under rainfall conditions such as these, and it is to the annual inundations of the Indus that the babul forests owe their origin and existence. The influence of the rainfall is of small

[1] Ind. Forester, xxxv (1909), p. 493.

importance compared with that of the floods. The Indus river, which is fed by the Himalayan snows and receives during its course through the Punjab plains the drainage of the four other large snow-fed rivers of that province, annually floods a large stretch of country on either bank. The flood season commences about the beginning of May with the melting of the snows and continues, with occasional interruptions, until July and sometimes later, the river thereafter subsiding until it reaches its winter level about the end of October. The extent and duration of the river floods vary greatly from year to year, and this variation has a marked influence on the conditions affecting forest growth.

The powerful river action causes the formation of new land in the shape of fresh alluvial deposits, and the loss of much existing land through erosion. The new alluvial river deposits (known locally as *kacha* ground) become densely covered in one or two years with a growth of *Tamarix dioica* and *T. Troupii* from water-borne seed, and of *kanh* grass (*Saccharum spontaneum*). Where the grass is not too dense, seedlings of *Acacia arabica* soon make their appearance amongst the tamarisk, the seed being dropped by cattle or conveyed by water: the tamarisk undoubtedly assists the babul to establish itself by protecting it from frost. The level of this new ground is gradually raised in course of time by subsequent alluvial deposits along its riverain edge, but as long as the land is subject to annual inundations the babul continues to flourish, other conditions being favourable. If, however, the flood water is shut out or the ground becomes elevated above the reach of ordinary floods the babul commences to languish, and unless there is sufficient subsoil moisture by percolation from the river or from perennial canals the trees die off if the flood water is withheld for three or four years: sufficient percolation from the river, however, is exceptional in ground not subject to floods. It has been estimated that the minimum depth of surface flooding necessary for good babul growth varies from 2 inches on the stiffest to 8 inches on the most porous soils. Deeper flooding is common, and the babul benefits rather than otherwise provided the water drains off at the end of the flood season, for prolonged inundation on low-lying ground is apt to kill off young plants which have been submerged.

Although the most flourishing babul forests are those which are now in riverain situations subject to annual floods, there exist also forests situated some miles from the river, the majority of which formerly received annual flood water. Within the past forty years, however, embankments constructed by the Irrigation Department along both sides of the Indus have shut off the forests from their annual supply of flood water. To a large extent this has resulted in the disappearance of the babul, its place being taken by the deep-rooted and hardier *Prosopis spicigera*. Where the babul has survived it is in a weakly condition, except where it obtains a more or less adventitious supply of water from the surplus drainage from neighbouring cultivation or from occasional breaches in the river embankments. Some of the forests are also irrigated from canals. For some years past steps have been taken to remedy this state of affairs by the construction of sluices in the river embankments, connecting with distributary channels leading into the forests, and by the embankment of forest boundaries to head up water. Whether or not these works will prove

remunerative remains to be seen, but in 1911 the Deputy Conservator of Forests in charge of the Sind circle recorded the following opinion : 'These schemes are bearing beneficial results, but in my opinion their total cost, together with the large annual outlay required to maintain them in efficient order, will be found in the future to be out of all proportion to the revenue likely to be yielded by the forests concerned. These irrigation schemes are complicated in many instances by the necessity on the one hand of protecting adjoining cultivation from forest flood water, on the other hand of not interfering with the customary water supply of cultivation beyond forest limits, and lastly by the difficulty of draining most of the forests so irrigated, at the close of the flood season. When and if a solution of these difficulties can be found, it almost invariably implies greater expense, both capital and recurring. I would therefore recommend that all inland forests should be gradually discarded whenever opportunities occur of acquiring riparian areas instead, so as to maintain undiminished, and to increase if possible, the total area under forest, while at the same time abolishing the difficulties, expense, and interference with more legitimate forest duties entailed by complicated schemes of irrigation.'

The alluvium of which the plains of Sind are formed consists of varying proportions of sand and clay, from pure sand to clayey loam. In places not subject to annual flooding patches of saline soil known as *kallar* often occur : such soil is produced by the evaporation of subsoil moisture containing salts in solution, resulting in the exudation of a whitish efflorescence on the surface of the ground, while the soil itself is usually darker in colour and moister than the normal soil. Babul does not grow on this saline soil where the salinity is at all marked ; it gives way to tamarisk, which in turn yields to *Salvadora*, while finally chenopodiaceous plants such as *Suaeda fruticosa* and *Salsola foetida* mark the last limit of vegetation when the salts become too concentrated for the existence of other species.

Acacia arabica is far more plentiful in lower Sind than in upper Sind. In the latter it is replaced to a great extent by the hardier *Prosopis spicigera*, owing no doubt principally to the greater intensity of the frost, the climate of lower Sind being milder owing to its proximity to the sea ; also the duration and extent of the river inundations is greater in lower than in upper Sind, and this further influences the distribution of the babul.

The most important associates of the babul in Sind are *Tamarix dioica* and *T. Troupii*, which are capable of standing soil conditions both too moist and too dry for the babul, but thrive well along with it ; *Populus euphratica*, which appears on new alluvium along with the babul; and, to a lesser extent, *Prosopis spicigera*. The last-named species usually appears when the land has become elevated above the reach of all but abnormal floods, and as a rule indicates a failing water-supply ; it is, however, also frequently met with in areas suitable for babul except for a dense growth of grass, the presence of *Prosopis* in place of babul being due to the greater power of resistance to suppression possessed by the former. Occasionally *Tamarix articulata* also appears with *Prosopis*. As the ground becomes drier *Salvadora oleoides*, *S. persica*, and *Capparis aphylla* make their appearance. Among other species, some of them introduced, which are occasionally found in the babul forests

are *Acacia Farnesiana*, *Albizzia Lebbek*, *Tamarindus indica*, *Parkinsonia aculeata*, *Zizyphus Jujuba*, *Azadirachta indica*, *Cordia Myxa*, *C. Rothii*, and *Ficus bengalensis*.

Northern and central India. *Acacia arabica* is scattered in greater or less abundance in suitable localities in the plains of the Punjab and United Provinces, and is frequently grown along canal banks: it is occasionally found in the drier parts of Bihar and Chota Nagpur, on embankments, waste lands, &c. In the Punjab it does not extend to the extreme north-west, where the cold in winter is too severe, but elsewhere it is one of the commonest trees of the plains, attaining a good size near water and in irrigated tracts. It is found in many parts of Rajputana and the Central India States, chiefly in the form of scattered trees in fields and waste lands and along roadsides, bunds, and railway embankments.

In the United Provinces the most important babul tracts are in the dry southern districts. In the sub-Himalayan tract the tree occurs only in certain isolated localities. Under the policy of afforestation promulgated by the United Provinces Government in 1912, the reservation of tracts of babul forest or of land capable of growing babul was commenced a few years ago in the Hamirpur and Etawah districts, with the idea of being extended to other districts as further experience in methods of afforestation is gained. It has now been definitely proved by the Kalpi plantation in the Jalaun district and the Fisher forest at Etawah that ravine lands in the southern districts of these provinces can be successfully afforested with babul; the rainfall here is between 30 and 40 in. These plantations are referred to on pp. 437–440, under 'artificial reproduction'.

Central Provinces and Berar. In the Central Provinces proper *Acacia arabica* occurs for the most part on open cultivated or waste lands and grazing grounds outside the large forest tracts, usually frequenting black cotton soil or alluvial ground in the neighbourhood of streams: it is also frequently met with on bunds and embankments.

The most important babul tracts are found in Berar, where the State babul forests extend over about 15,600 acres, while an additional area of public land (grazing grounds, &c.), roughly estimated at 12,500 acres, either contains crops of babul or is capable of supporting them. The tree also occurs in considerable abundance over private lands, along boundaries between cultivated fields, along banks of streams, and elsewhere. According to Mr. Shrinivasulu Nayadu[1] the distribution of the babul in Berar is determined mainly by situation, soil, and altitude. The underlying rock consists throughout of Deccan trap, and there is a varying depth of black cotton soil over it. The topography of the country is characterized by three main features: (1) on the north the Gawilgarh hills (the Melghat), averaging 3,400 ft. in elevation; (2) on the south the Ajanta hill range (the Balaghat), comprising undulating plateaux about 1,600 to 2,200 ft. in elevation; and (3) between these two hill ranges the broad valley of the Purna river system, known as the Payanghat plain, 800 to 900 ft. in elevation. The Gawilgarh hills are unsuitable for babul, since even in the ravines and valleys the substratum is dry, while frosts of some severity occur: the rainfall here is about 58 in. In the Balaghat babul

[1] *loc. cit.*, p. 491.

occurs to a greater or less extent along the banks of streams, and on cultivated and other land where there is sufficient immunity from frost and weeds: the rainfall of this tract averages 38 in.

The Payanghat plain is the important babul-bearing tract of Berar, and it is here that most of the State babul *bans* are situated. In this plain overlying the Deccan trap is a deep alluvial deposit, often 150 ft. in depth. Black cotton soil occurs at the surface, with yellow calcareous loam beneath; this loam often appears at the surface, and is less favourable to tree growth than the black cotton soil. Deposits of silt are frequent in the river valleys and along the sides of streams. The water-bearing stratum is at a considerable depth, but the superficial strata are sufficiently retentive of moisture to support the growth of babul. The rainfall in the Payanghat tract averages 30 in., rain falling mainly during the south-west monsoon from June to September, with occasional showers from November to January. Frost is of rare occurrence; indeed, wherever it occurs in Berar the babul is easily capable of standing the winter cold, suffering only in abnormal years, as in January 1911. Babul forms about 90 per cent. of the tree growth of the Payanghat, its chief companions being *Acacia leucophloea*, *A. eburnea*, *Prosopis spicigera*, *Dichrostachys cinerea*, *Balanites Roxburghii*, *Azadirachta indica*, *Zizyphus Jujuba*, and *Phoenix sylvestris*. Common species of the undergrowth are *Cassia Tora*, *C. auriculata*, and *Capparis grandis*. In situations favourable to the babul this tree forms pure crops, the associates becoming more prominent where the black cotton soil gives place to calcareous loam or shallow soil. *Phoenix sylvestris* predominates on swampy ground. Babul occurs most plentifully and shows the most vigorous growth in the deep moist soil in the neighbourhood of streams and particularly along the Purna river: in such places it benefits by the annual inundations during the rainy season. Both the *telia* and the *kauria* varieties are common, the former seeking the localities with deep moist soil and the latter being more plentiful on the higher and drier ground away from the streams, or where there are calcareous deposits near the surface, or where the salinity of the soil becomes marked: the growth of the *kauria* is much slower than that of the *telia* variety, and the rate of growth of the latter decreases away from the streams.

Bombay Deccan. The principal babul tracts of the Bombay Deccan are situated in the Khandesh, Nasik, Ahmednagar, Sholapur, Poona, and Satara districts. The actual area of these tracts is difficult to estimate, as the babul is restricted to certain localities and is not distributed over the whole forest area. In 1908 the total area of State babul forests was estimated at 45,000 acres. The forests are for the most part widely scattered over cultivated lands, usually in isolated patches of comparatively small size, and along the banks of rivers. The underlying rock is mainly trap, over which there is frequently a varying depth of black cotton soil favourable to the growth of babul, but on the higher ground away from rivers the soil usually becomes a dry shallow *murram*, the result of the disintegration of the trap, or a calcareous *kankar* unfavourable to babul. The best babul tracts are invariably situated on deep sandy alluvium along the banks of rivers and streams subject to annual inundation. Here the *teli* variety flourishes and often forms dense crops. On the deep black cotton soil of the lower ground the babul also

flourishes well, but on the higher ground away from the rivers, where the soil is dry and shallow, the *teli*, variety gives place to the *kavadi* (*kauria*), the crop becomes more open and the trees are stunted; finally on the poorest localities, where the soil consists of deposits of *kankar*, the babul may disappear altogether and give place to *Acacia eburnea*, *A. Latronum*, *A. Catechu*, *Balanites Roxburghii*, *Capparis aphylla*, and occasionally *Azadirachta indica* and a few other species. These species are characteristic of the poorest types of babul forest. Among other associates on comparatively dry ground are *Zizyphus Jujuba*, *Prosopis spicigera*, *Albizzia odoratissima*, *Diospyros Melanoxylon*, *Acacia leucophloea*, *Anogeissus latifolia*, and others, while on the rich alluvium along the rivers *Pongamia glabra* and *Eugenia Jambolana* make their appearance. The babul crops occur in various stages of development: under previous working plans most of the old and deteriorating trees have been cut out, and the majority of the more promising crops are of various ages up to 20 or 30 years.

The climate of this region is a dry one, the rainfall, which is uncertain, varying from 18 to 30 in., though the tree thrives best where the rainfall is over 25 in. The absolute maximum shade temperature varies from 108° to 112° F., and the absolute minimum from 37° to 45° F. From March to May there is intense heat and drought, which is detrimental to reproduction and development on all but the deeper and richer soils where the roots are able to penetrate to the moist strata: the annual inundations on the alluvial riverain tracts are therefore of the greatest importance in producing favourable soil conditions to counteract the adverse climatic factors.

Southern India. The babul is found in greater or less abundance in suitable localities throughout the plains in the drier parts of the Madras Presidency, Hyderabad, Mysore, and Travancore, where the rainfall varies from 20 to 40 in., but not in the moist regions of the west coast. In Madras it occurs in fair abundance in several districts, particularly in Kistna, Kurnool, Anantapur, Guntur, Bellary, Chingleput, and Tinnevelly. It is usually found on black cotton soil, but also occurs on other soils, for example on ferruginous loam overlying metamorphic rocks in Bellary, where it is stunted and much damaged by grazing. In some districts, particularly in Tinnevelly, good crops of babul are found in the beds of numerous tanks scattered about the country. Many of these have been formed into reserved forests and improved by artificial sowing; they constitute an important source of supply of fuel and agricultural and domestic timber. Among the more usual associates of the babul in Madras are *Acacia planifrons*, *A. Latronum*, *A. leucophloea*, *Prosopis spicigera*, *Cassia Fistula*, *C. auriculata*, and *Azadirachta indica*.

Leaf-shedding, flowering, and fruiting. *Acacia arabica* is hardly ever quite leafless, though on very poor soils it is sometimes bare for a short time in April–May. The young leaves appear from March to May, the old leaves commencing to fall before they appear and continuing to do so while the young leaves are sprouting. The flowering season is somewhat irregular, varying not only according to locality but also in the same locality. Flowering is most general in the rainy season, from June to September or October, but trees may be found in flower as late as December or January. The flowers are in fragrant yellow globose heads about 0·5 in. in diameter. The young

fruits develop rapidly; the time of ripening varies according to locality, but is usually from April to June, or earlier in southern India. In the Peninsula the *kauria* variety is said to ripen in January and February. In Sind the tree flowers as a rule twice a year, once in June–July and again in November–December. The pods from the first flowering ripen about October, but are usually poor in quality and quantity: those of the second flowering ripen about May, and as a rule give a better crop. The pods (*telia* or typical variety) are 3–6 in. long by 0·5 in. broad, compressed, whitish tomentose, deeply constricted between the seeds, eight- to twelve-seeded. In the *kauria* variety the pods are more shortly stalked, about 0·75 in. broad, and very little constricted between the seeds. The seeds (Fig. 161, *a*) are compressed, ovoid, dark brown, shining, with a hard testa; about 200 to 300 weigh 1 oz. They retain their vitality for some years if carefully stored. They are liable to beetle attacks even when still on the tree.

Trees commence to bear fruit at an early age, usually at about five to seven years or somewhat later in Sind. They seed annually as a rule: in Sind the crop of pods is sometimes affected if the winter is severe, but this is not frequent. The pods are usually blown from the trees by the dry winds of the hot weather. They dehisce with difficulty, and if not eaten by animals may lie on the ground until the valves rot, the seed remaining ungerminated until it escapes in this way, though it is exposed in the meantime to the attacks of insects, rats, and squirrels. In exceptional cases the seeds may germinate inside the decaying pod, a line of germinating seeds being found partially enclosed in the pod: such cases are rare. Seed may be removed from the pods by drying the latter and pounding them. In tests of Berar seed carried out at Dehra Dun in 1911 and 1912 the *telia* variety gave the highest percentage of success, the *kauria* came next, and the *ramkati* gave the lowest percentage.

The pods are readily eaten by sheep, goats, and cattle, and the seeds are ejected by them. As far as recorded observations go the seed, although it does so in the case of bovine animals, seldom passes completely through sheep and goats, but is ejected by them from the mouth during rumination; the seeds are, it is true, found among their droppings, but this is because of the fact that rumination ordinarily takes place where the animals are herded. The fermentation and moistening which the seeds undergo before their ejection undoubtedly assists germination, and seed which has been ejected by animals is also held to be less liable to insect attacks than seed collected straight from the pod. The superiority of seed collected from goat and sheep pens is generally recognized, and seed so collected is extensively used for artificial sowings.

Experiments carried out in Sind in 1910–11 and 1911–12 to test the fertility of seed obtained from goat and sheep pens and those obtained direct from pods gave the following results:

	From pens. per cent.	From pods. per cent.
Sukkur division	13	6
Hyderabad division	56	43
Naushahro division	70	35
Jerruck division	51	31

An experiment in the Sukkur division to ascertain if the fertility of seed is impaired by prolonged immersion in water showed that immersion extending

up to five weeks had no harmful effect, a fact which is of importance in tracts inundated for some time.

GERMINATION (Fig. 161, *b–d*). Epigeous. The radicle emerges and descends. The hypocotyl elongates, arching very slightly or not at all, and raises the cotyledons above ground; as a rule the testa is carried up over the cotyledons, falling with their expansion.

THE SEEDLING (*telia* variety, Fig. 161).

Roots: primary root long, thick in vigorous plants, otherwise thin and wiry, terete, tapering, light brown: lateral roots numerous, short, fibrous: small nodules present. *Hypocotyl* distinct from and thicker than young root, 0·7–1·3 in. long, terete, cylindrical or tapering slightly upwards, expanded in a ring at the base, pale green, glabrous. *Cotyledons*: petiole 0·1 in. long, thick, glabrous: lamina 0·5 in. by 0·4 in., plano-convex, fleshy, less than 0·1 in. thick, elliptical or ovate, apex rounded, base sagittate, entire, glabrous, pale green beneath, darker above. *Stem* erect, somewhat zigzag at the nodes, wiry, pale green, glabrous; internodes variable in length, usually 0·2–0·4 in. long in young seedlings. *Leaves*: first pair opposite or sub-opposite, subsequent leaves alternate. Stipular spines in pairs at the base of the leaves at first 0·1 in. long, increasing to 0·5 in. long after a few nodes. First pair of leaves paripinnate, up to 1 in. long, with about four pairs of leaflets 0·1–0·2 in. long, or second leaf sometimes bicompound, subsequent leaves bicompound, first with one pair then with two pairs of pinnae, the number of pinnae increasing subsequently.

Under favourable conditions the development of the seedling is rapid from the commencement, plants which germinate about July sometimes reaching a height of 3 to 4 ft. by December. Experiments carried out at Dehra Dun indicate that the chief factors stimulating rapid development are an abundance of light and a loose soil free from weeds: irrigation also stimulates growth, but in the seedling stages weeding and loosening of the soil are even more important. The climate of Dehra Dun, it may be noted, is damper than in any region where the tree grows naturally. The development is poor on stiff clay. Experimental plots at Dehra Dun, some weeded and others not weeded, some irrigated and others not, showed the following rate of growth during the first season in respect of the three varieties of babul:

Acacia arabica: growth of seedlings under different conditions, Dehra Dun.

		Irrigated.		Unirrigated.	
Variety.	Particulars.	Weeded.	Unweeded.	Weeded.	Unweeded.
Telia	Number of plants at end of season	99	15	28	12
	Height . .	0 ft. 3 in.–2 ft. 0 in.	0 ft. 2½ in.–1 ft. 0 in.	0 ft. 9 in.–3 ft. 6 in.	0 ft. 2 in.–1 ft. 1 in.
	Condition . .	Chiefly vigorous	Weakly	Chiefly vigorous	Weakly
Kauria	Number of plants at end of season	36	80	38	2
	Height . .	0 ft. 1½ in.–3 ft. 8 in.	0 ft. 3 in.–2 ft. 0 in.	0 ft. 3 in.–3 ft. 6 in.	Larger 0 ft. 11 in.
	Condition . .	Chiefly vigorous	Weakly	Chiefly vigorous	Weakly
Ramkati	Number of plants at end of season	16	2	29	12
	Height . .	0 ft. 10 in.–4 ft. 3 in.	0 ft. 3 in.–0 ft. 5 in.	0 ft. 3 in.–4 ft. 0 in.	0 ft. 2½ in.–0 ft. 11 in.
	Condition . .	Vigorous	Weakly	Vigorous	Weakly

Approximately the same quantity of seed was sown in each plot, but the number of seeds sown was not recorded.

FIG. 161. *Acacia arabica*—SEEDLING × $\frac{3}{4}$

a—Seed   b - d—Germination stages   e - h—Development of seedling during first season

These results demonstrate the great importance of weeding, irrespective of irrigation.

During the first four years the maximum height of a plot of seedlings at Dehra Dun from seed sown in 1911 was as follows:

End of first season; maximum height 1 ft. 7 in.
End of second season; maximum height 6 ft. 8 in.
End of third season; maximum height 15 ft.
End of fourth season; maximum height 16 ft., girth 9 in.

This plot was regularly weeded, but not watered, and the soil was a deep loam.

The influence of a loose porous soil on the development of the seedling is well illustrated in the case of sowings where the seeds are sown along ridges of loose earth. This system has been found very successful in dry localities; vigorous plants raised in such sowings have thick stems and strong side branches, and may reach a height of over 4 ft. in the first season, whereas seedlings from sowings on level ground in the same place may attain a height of not more than a few inches, without well-developed side branches, and in many cases are unable to survive the ensuing dry season. A feature of the babul seedling is the long taproot, which is developed at an early age, and is a necessary provision in the dry localities in which the tree grows, and particularly on black cotton soil, which is sodden in the rains and dry and cracked in the dry season. A vigorous plant on a weeded ridge sowing of June 1914 in the Hamirpur district, United Provinces, was dug up in December 1914 and found to have a taproot 5 ft. long and ½ in. thick at the top.

The seedling is a strong light-demander, and will not tolerate suppression of any kind. In experimental sowings at Dehra Dun under different degrees of shade it was found that the development was always better in full sunlight than under even the lightest shade. In groups of seedlings the stronger individuals quickly suppress the weaker ones and kill them out.

During germination the radicles are very liable to damage by insects in the case of seed lying on the surface of the ground. Another serious cause of mortality is the damping off of young seedlings in sodden grass or weeds during the rains. In inundated tracts, as in Sind, seedlings are sometimes killed by an excess of water in low-lying areas where the flood water lies for some time after the end of the season. The seedlings are decidedly tender to frost: in Dehra Dun the *telia* variety was found to be somewhat hardier than the *kauria* in this respect, and seedlings on clear weeded ground suffered less than those growing in grass. Young plants, however, have good recuperative power from the effects of frost, sending out new shoots after being killed back. In dry climates drought is undoubtedly the most serious cause of mortality among seedlings; the *kauria* variety is more drought-resistant than the *telia*.

The young plants are also subject to injury from animals: the spines which are developed at an early age ordinarily protect them from damage by domestic animals other than browsers, of which goats are the worst. They are frequently browsed by deer and antelopes and eaten by hares. The most serious animal pest, however, is the Indian gerbille or antelope rat (*Gerbillus indicus*), which gnaws the bark of the seedlings, or cuts through the shoot or root. Mr. Shrinivasulu Nayadu[1] states that the injury begins when the

[1] *loc. cit.*, p. 500.

seedlings are weeded in the rains, but becomes very noticeable when the harvest is over and there is no food in the fields to invite the rats. These animals appear to multiply most freely in dry seasons, heavy rain being injurious to them. The deep cracks in the black cotton soil are specially favourable to them, since they live in deep burrows. The rats rear their young, eight to twelve at a time, in nests built about 2 ft. above ground in the interlaced branches of babul thickets, and a knowledge of this fact is useful in helping to reduce their numbers.

SILVICULTURAL CHARACTERS. *Light.* *Acacia arabica* is a strong light-demander, and will not tolerate suppression of any kind at any period of its existence. Young natural crops are often dense, and for some years the saplings may grow up without many side branches, but they thin each other out and the trees develop broad and full though somewhat light crowns. When grown in a free position the tree maintains a bushy form for many years, though the main stem is distinguishable.

Root-system. The young plant, as already mentioned, develops a long taproot from the commencement, and strong lateral roots are also formed early. The subsequent development of the root-system depends to some extent on the locality. Under normal conditions on dry ground the taproot reaches a considerable length. Mr. Ribbentrop states:[1] 'I have known them to be 25 ft. long, and under certain conditions they may reach much lower.' In addition to the taproot a strong superficial root-system is produced. On shallow soil the taproot branches without reaching any depth, and the plant is liable to die of drought. On inundated land the root-system is largely superficial.

Root-suckers. The babul has not as a rule been observed to produce root-suckers regularly, but Mr. A. W. Lushington says:[2] 'When pulling up what appeared to be seedlings of babul (*Acacia arabica*) in the Kistna district, they were found not to be seedlings at all, but sucker-shoots.' He mentions further that these suckers are produced especially when trees have been felled or where the roots have been exposed, and that he has found that a very fair percentage of what he always supposed to be seedlings have been these sucker-shoots. Mr. P. M. Lushington,[3] writing of babul areas in the Guntur district, Madras, says: 'Hitherto I have believed that the coppice resulting from babul was practically unproductive, and have for many years advocated the wounding of the roots with a view to producing root-shoots.' The Deputy Conservator of Forests, Sind circle, wrote in 1911: 'Experience here tends to show that babul has very limited powers of reproduction by coppice-shoots or root-suckers.' Other writers have expressed doubt as to the capacity of the tree for producing root-suckers. So far as observations go at present, therefore, it may be considered as established that the babul, though it may not produce root-suckers universally, does produce them in some localities and under certain conditions, this tendency being stimulated if the trees are felled or the roots exposed.

Coppicing power. The coppicing power of the babul varies greatly. Throughout the greater part of its habitat it coppices poorly; this, from

[1] Ind. Forester, xxv i(1900), p. 136. [2] *Ibid.*, xxx (1904), p. 163.
[3] Inspection note, 1912–13.

observations recorded by numerous forest officers, appears to be the case in Sind, Berar, the Bombay Deccan, and many parts of southern India, for although stumps up to about 6 or 7 in. in diameter frequently produce coppice-shoots, these in the majority of cases do not develop, remaining small and bushy or dying off altogether. Larger stumps cannot be relied on to produce coppice-shoots, and in general coppice as a regular means of reproduction is held to be out of the question.

Certain important exceptions have, however, been recorded, notably from Guntur in the Madras Presidency, where the babul has been regularly worked under the coppice system for some years. Mr. P. M. Lushington, after inspecting one of the babul tracts in Guntur, wrote: 'Hitherto I have believed that the coppice resulting from babul was practically unproductive. . . . A glance at this area was sufficient to show me that my opinion was unsustainable. Here we have a well established working series in which coppice reproduction is the main feature. The working is fully justified by results, for I saw established coppice seven years old which, though it did not cover the whole area, was well on its way to establishing a fairly thick forest.' Other recorded observations indicate that in certain parts of Madras, at all events, coppice reproduction can be relied on to a fair extent provided the trees felled are not of large size.

The precise reason why babul coppices in some localities and not in others has not yet been satisfactorily explained. That flooding, provided it is not of excessive duration or intensity, is a possible factor is indicated from the observations of Mr. J. S. Scot, who notes that all the best coppice areas in Guntur are those which are under water for some period each year.[1] There must, however, be other factors at work, otherwise the babul in Sind would coppice freely.

Pollarding. The babul usually pollards well, and is freely lopped for thorn fences and fodder.

Susceptibility to injuries. (i) *Storms.* Trees on inundated ground which has become soft are liable to be uprooted on an extensive scale; this is particularly the case in Sind. Where the fungus *Fomes Pappianus* is prevalent trees are frequently uprooted owing to decay in the roots, or the stems or large branches may be snapped in two owing to the brittleness of the affected wood.

(ii) *Frost and drought.* The tree is frost-tender, but is drought-resistant so long as the subsoil moisture holds out. The mortality among trees in Sind after the land ceases to be regularly inundated has already been referred to. In Sind damage by frost is less severe on inundated lands than on lands which have passed beyond the stage of annual flooding.

(iii) *Fire.* The babul is not a fire-resistant species, and is often killed outright where much inflammable grass is present.

(iv) *Animals.* Among grazing animals goats and camels are the most destructive, and sheep and buffaloes are also harmful. Cattle are the least harmful, and may even be beneficial, if admitted in small numbers, in keeping down grass and weeds and thus reducing the cover for rats and hares and the amount of inflammable material. Damage to young plants by deer, antelopes, hares, and rats has already been referred to.

[1] Ind. Forester, xxxviii (1912), p. 396.

(v) *Insects.* The two most destructive insect pests of the babul are the beetles *Coelosterna scabrata*, Fabr., and *Psiloptera fastuosa*, Fabr., an account of which by E. P. Stebbing is contained in *Forest Bulletin* No. 12 of 1912. The former, which is the more dangerous of the two, is a root-boring longicorn, the grubs of which tunnel in the roots and kill young trees: the imago strips the bark from the leading shoots and branches of young trees. The latter beetle is a buprestid, which as far as is known attacks trees only in its mature stage, stripping the bark off the shoots and branches.

(vi) *Fungi.* Much damage is caused in Berar by the fungus *Fomes Pappianus*, Bres. This fungus attacks the heartwood of the stem and branches and spreads into the roots, causing the wood to become brittle, and in severe cases to crumble away: infected trees are thus liable to be blown over or to have their stems and branches snapped in two by wind. The fungus does not attack young healthy trees, but only those which are in an unhealthy condition or have ceased to grow vigorously owing to injury or to old age: it attacks isolated trees as well as those growing in dense crops. It has not yet been ascertained whether the fungus spreads underground through the roots by means of mycelia or through wounds above ground by means of spores, or both.

Measures which have proved efficacious in keeping the fungus in check are: (1) to remove all sporophores from infected trees; (2) to cut out badly infected trees; (3) to execute regular thinnings in young crops, removing sickly stems and promoting vigorous growth in those retained; (4) to cultivate the soil with field crops after the babul crop has been removed, and to keep the young babul crop healthy by hoeing the ground and promoting soil-aeration.

(vii) *Lopping.* Lopping for fodder and thorn hedges is a source of much injury to the babul: in some cases the lopping takes the particularly destructive form of half cutting through the branches and bending them down to be within the reach of goats and cattle, a jagged wound being thus formed: small trees are similarly cut half through a few feet from ground-level and broken down. Although the babul has great capacity for healing wounds, jagged wounds formed by rough methods of lopping do not heal, and become centres of infection by rot. It is by no means improbable that lopping may prove to be one of the chief causes of the spread of fungus attacks.

Natural reproduction. Under natural conditions germination commences early in the rainy season and continues for some time. Much moisture and warmth are necessary to effect complete germination, and without these the seed may lie dormant for two seasons or more and then germinate if conditions are favourable. Experiments at Dehra Dun in which seed was sown under varying degrees of shade and temperature showed that germination was considerably retarded under even slight shade, owing to the reduction of temperature, and that when it did take place the seedlings were unable to persist for any length of time in the absence of complete light.

The dangers to which the seedling is exposed during and after germination have been mentioned above under 'the seedling', and these are all factors inimical to natural reproduction.

It may be said generally that the conditions essential for the stimulation of vigorous natural reproduction are: (1) complete sunlight, (2) abundant

moisture, (3) loose soil, and (4) absence of grass and weeds. Apart from these factors germination is greatly stimulated if the seeds have been swallowed by animals and ejected by them.

The effect of complete light may be seen in any babul tract. Successful reproduction never appears under or even close around seed-bearers, but always in open gaps fully exposed to light. The effect of abundant moisture is seen in riverain tracts, where successful reproduction depends largely on the extent of the annual floods, failure usually following abnormally dry seasons. In tank beds in Madras it is noticeable that natural reproduction is most plentiful where the ground is annually inundated and scanty on the higher ground. Seedlings are, however, sometimes killed out by excessive flooding, not only in riverain tracts but also in depressions on flat ground. In riverain tracts it is probable that considerable loss is caused by seeds and seedlings becoming buried in thick deposits of silt.

The effect of loose soil is most marked, since it has a direct influence on the development of the taproot, and causes soil-aeration and the retention of soil moisture. For this reason vigorous natural reproduction frequently springs up on ploughed land and on new embankments, while on hard unworked ground reproduction is usually scanty or absent. The presence of rank grass and weeds is one of the factors most adverse to the establishment of natural reproduction, babul seedlings being particularly sensitive to suppression. In this respect grazing is advantageous in keeping down a rank growth of grass. One of the worst weeds in babul tracts of the Peninsula is *Cassia Tora*, which sometimes forms a dense soil-covering and effectually prevents reproduction.

The importance of animal agency in promoting the germination of the seeds has already been alluded to. Apart from this grazing animals perform a most useful function in spreading the seed over ground on which they are herded, and which is usually kept free of grass and weeds. Both in inundated riverain tracts and on other lands subject to grazing the seed is brought on to the ground very largely by animals, and the existence of many babul groves may be traced directly to their agency. The young seedlings as a rule require protection from cattle only for about six months or less, but protection from goats is necessary until the plants are well out of their reach.

A consideration of the factors just enumerated does not, however, always solve the question of natural reproduction, the presence or absence of which in patches of varying extent for no apparent reason is not always easy to account for. Thus good patches of even-aged reproduction frequently occur in places where attempts to regenerate artificially by scattering seed on the ground have resulted in failure, and this would indicate that there may be special reasons for such natural reproduction establishing itself only under certain favourable conditions, whether seasonal or otherwise.

Artificial reproduction. The choice between direct sowing and transplanting from the nursery is easily decided, for owing to the sensitiveness of the taproot transplanting on a large scale is out of the question for forest purposes. Numerous transplanting experiments at Dehra Dun, in which roots and stem were in some cases pruned and in others left intact, resulted in almost complete failure. Only when very small plants of the first season were transplanted early in the rains with great care, and watered in dry weather,

was even slight success attained. On a large scale the cost of such operations would be prohibitive considering the proportion of failure likely to be met with.

Direct sowings, however, are very successful, provided certain precautions are observed. The chief of these are as follows:

1. *Choice of site.* In arid climates, as in Sind, the formation of plantations is useless unless natural or artificial irrigation can be secured. It is doubtful if plantations could ever be profitable in regions with a rainfall of less than 20 in., except on deep rich moist soil, such as that found along the sides of rivers and streams. In any locality sowings on poor shallow soil such as *kankar* deposits will never produce anything but poor stunted growth; babul sowings should be confined to the more fertile ground, the poorer soil being reserved for neem (*Azadirachta indica*), *khair* (*Acacia Catechu*), and other trees which are not exacting. Localities subject to severe frost should be avoided.

2. *Treatment of soil.* Except in certain flooded riverain lands, thorough loosening of the soil and removal of matted grass roots are necessary for the success of babul sowings; not only is this the case before the seed is sown, but in places where the soil is apt to cake or crack it is also necessary subsequently, and can be effected, where the soil is not too stiff, by means of hand ploughs. In black cotton soil it may be necessary to fill up the cracks which form in the dry season.

3. *Preparation of seed.* Where possible seed collected from sheep and goat pens should be employed, as this germinates more quickly and gives a higher percentage of success. Failing this a common practice is to soak the seed in water or heap it up with moist cow-dung to stimulate germination.

4. *Weeding.* Although exceptional cases occur where weeding is found to be unnecessary, as in the flooded riverain tracts of Sind, as a general rule systematic weeding of the young crop for the first two or three years is essential.

5. *Thinning.* In the United Provinces and Berar it has been found of great advantage to commence thinning out the young plants in the first year and to continue annual thinnings for a few years, followed by periodical (usually 5-yearly) thinnings later. The early thinnings consist in spacing the plants in such a way as to prevent contact of the branches.

6. *Admission of grazing.* In some localities grazing of all kinds is excluded during the earlier years of the plantation. In Berar, on the other hand, success has been found to depend largely on the admission of light grazing by cows and bullocks (not sheep and goats) from the end of the first rains onwards, in order to keep down the growth of grass, which harbours rats, hares, and beetles, and also suppresses the seedlings. In order to secure the utmost benefit from grazing, the lines are widely spaced, usually 12 ft. apart, the plants are regularly thinned, and their lower branches are pruned in order to allow the cattle to obtain access to the grass between the plants.

Various examples of sowings in different localities are described below. The method of sowing must necessarily vary under different conditions, but it has now been conclusively proved that in dry regions on non-irrigated culturable land the method which has succeeded best, and is also very cheap, is that of line sowings in conjunction with the raising of field crops, which has been practised on a considerable scale in Berar. The ridge sowings employed

in the United Provinces in the Hamirpur district and elsewhere also give good promise of success, though they are somewhat costly.

Experimental sowings at Dehra Dun. In numerous experimental sowings carried out at Dehra Dun it was found that both irrigated and unirrigated line sowings on loosened soil succeeded well, provided the lines were kept thoroughly weeded and the soil was worked up periodically along the lines. Wherever weeds were allowed to get the upper hand the babul was killed out by the middle of the second season. In the irrigated line sowings the seed was sown along the base of the ridge of earth thrown up alongside an irrigation channel 1 ft. wide and 9 in. deep. Unirrigated line sowings along with field crops were found to give excellent results where the seed was sown along a loosened strip 2 ft. wide kept clear of crops, the crops being sown in the intervening spaces. Where the crops were sown continuously over the area the young babul plants were suppressed and killed out. Thorough weeding and periodical loosening of the soil along the lines were found to be necessary for satisfactory development. One pound of seed was found sufficient for 270 ft. length of line. The field crop employed was the lesser millet or *mandwa* (*Eleusine coracana*, Gaertn.), which was sown early in June and reaped in October.

Berar: agri-silvicultural sowings. The sowing of babul in conjunction with the raising of field crops has been carried out systematically in Berar for several years past, and has proved much more successful and economical than any other form of artificial reproduction; efforts are therefore constantly being made to extend this method of reproduction and popularize it among cultivators.

Under the Berar system the coupe of the year is auctioned, the purchaser being required to grub up the stumps after felling the trees, and to cultivate the land with field crops under a lease. Cultivation with field crops alone is carried out for two successive years, and in the third year babul seed is sown in lines with cotton as the intervening field crop. The two years' preliminary cultivation is considered necessary (1) to enable the lessee to recoup the cost of digging out the roots of the felled trees, (2) to ensure the thorough cleaning and aeration of the ground, and (3) to remove all traces of the fungus *Fomes Pappianus* in the soil. The babul seed employed is that which has been swallowed and ejected by goats; it is collected free of charge by the lessee. In the earlier sowings the lines of babul were sown 6 or 7 ft. apart, with three or four intervening lines of cotton; this distance between lines was found to be too close to admit of the light grazing necessary to keep down the growth of grass after the removal of the field crops, and the distance now commonly adopted is 12 ft.

The lessee is required to weed the lines of babul thoroughly and to exclude goats from the area after the babul seed is sown. Provided he abides by the conditions of his agreement the lessee is allowed to retain possession of the area, free of assessment, until January of the year following the sowing of the babul, and is then rewarded at the rate of Rs. 2 per acre fully stocked with babul, suitable deductions being made for failures. The area is then taken over by the Forest Department and at once opened to light grazing of cows and bullocks—one animal per two acres—during the rainy season, in order to keep down the growth of grass and weeds. In places where growth is slow

or failures have occurred, or where there is a danger of the young plants being overtopped by a rank growth of grass, the lessee is permitted to cultivate for a fourth season on condition that he weeds the lines of babul and sows seeds wherever the first sowings have failed.

An important modification has been introduced in certain localities in order to combat the ravages of the beetle *Coelosterna scabrata*. This insect in the imago stage finds harbourage in grass and weeds, and hence the ground requires to be kept clear of such growth for as long as possible. This is effected by permitting the lessee to cultivate between the lines of babul for as long as he wishes, provided he weeds along and between the lines and prunes off the lower branches of the babul to give cattle access to the lines. A further precaution adopted is to sow neem (*Azadirachta indica*) seed along with the babul in the proportion of one of the former to three of the latter : the two species grow well together.

Thinnings are considered essential for the healthy development of the crop. The young plants are thinned out annually during the first few years, until they are as far apart as the distance between the lines, and thereafter at intervals of five years. The pruning of side branches is also carried out.

This system of cultivation promotes vigorous growth, the thorough working of the soil and the weeding causing the babul roots to strike deep down from the commencement. A height of 4 to 8 ft. is attained in two years on deep moist soil, and in three years on drier and poorer ground. It is proposed to work the plantations on a rotation of twenty or twenty-five years in order to supply timber as well as fuel.

Berar : broadcast, mound, patch, and strip sowings. Apart from the agri-silvicultural method of raising babul plantations in Berar, the following methods have given satisfactory results, though the success has never been as great as that of sowing with field crops : [1]

1. Broadcast sowings at a cost of about 4 annas an acre have been successful on areas which flank small streams : elsewhere they have usually proved a failure.

2. Mound sowings have been made in areas subject to floods or in swampy or water-logged situations. Low mounds 6 in. high and 2 ft. in diameter, spaced 8 ft. by 4 ft., have given good results : the cost has not exceeded Rs. 3 per acre.

3. Patch sowings have been made in blanks amongst young growth of babul or other species already on the ground. Patches 2 ft. by 1 ft., dug and cleared of roots to a depth of 6 in. and spaced 8 ft. by 4 ft., have given good results : the cost should not exceed Rs. 2–8–0 per acre.

4. Strip sowings have been largely carried out. Strips 10 ft. apart are made by means of three confluent plough furrows, each strip being about $2\frac{1}{2}$ ft. broad : the cost has been from Rs. 2–8–0 to Rs. 2–12–0 per acre.

In all these sowings success was found to depend largely on the admission of light grazing of cows and bullocks in order to keep down the grass ; as a rule no grazing was permitted during the monsoon in which the sowings were made, but from October onwards the admission of cattle commenced. Goats and sheep were rigidly excluded.

[1] Shrinivasulu Nayadu, *loc. cit.*, p. 491.

Bombay Deccan: agri-silvicultural sowings. Mr. L. S. Osmaston[1] has described the results of experiments in sowing babul and other species in the Bombay Deccan in dry localities where the rainfall is scarcely 20 in. He states that in his experience the only successful method of restocking the forests of these dry tracts is by sowing in conjunction with the raising of field crops: the crops employed here are chiefly sesamum, cotton, and the lesser hemp.

Operations are conducted where possible by lessees and not departmentally. A two years' lease is given, and two different methods have been tried:

1. In the first year the lessee is allowed to cultivate field crops, the tree seeds as well as field crops being sown in the second year, one line of tree seeds to three lines of field crops, the distance between the lines of tree seeds being about 4 ft.: the lines are weeded twice in the first rains.

2. Tree seeds are sown in the first year of the lease in broad strips 4 ft. apart—four lines 1 ft. apart—alternating with strips of field crops 8 ft. broad: the lessee cultivates field crops between the strips of tree seedlings in the second year of the lease, and also weeds and sows up blanks.

The first method had been tried only recently, but if experience in Berar holds for the Bombay Deccan, the distance between the lines of babul may be found too small. The second method promises well, but success must depend largely on favourable rainfall: babul seedlings $3\frac{1}{2}$ years old had a maximum girth of 11 in. and a maximum height of 16 ft. In departmental sowings on this principle the cost of formation—including cost of collection of seed and weeding, but not of supervision—for the first three years amounted to Rs. 28–11–0 per acre: the receipts from the produce of the agricultural crops amounted to Rs. 32 per acre, leaving a profit of Rs. 3–5–0 per acre.

In the Poona district deep ploughing with broadcast sowing of seeds which have been swallowed and ejected by sheep and goats has proved fairly successful.

Sind: broadcast sowings with and without field crops. In Sind broadcast sowings are carried out to supplement natural reproduction on new riverain land subject to annual inundations. The seed is scattered on the water when the floods are subsiding and sinks into the ground.

Broadcast sowings in conjunction with the raising of field crops are carried out extensively on land above the reach of ordinary floods which is capable of being irrigated by lifts. The babul seed is sown broadcast along with the field crops in the first year; in the second year the area is again ploughed up and a second field crop is sown together with more babul seed. The second ploughing seems to do little damage to the babul crop, the cultivator learning to avoid the patches of babul, and the results attained are highly successful. The cultivator pays the current rate of land revenue during the two years in which he cultivates, and is also bound to irrigate the young babul crop for a third year and to protect it by means of thorny hedges. These plantations are formed entirely free of cost.

United Provinces. The babul has played an important part in afforestation schemes in the southern and drier parts of the United Provinces, where

[1] Ind. Forester, xxxiii (1907), p. 265.

the normal rainfall varies from 30 to 40 in. The sowing of babul, chiefly on an experimental scale, has been carried out both on ravine land and on flat or gently undulating ground. The principal examples of the former are the Kalpi plantation and the Fisher forest at Etawah. The Piprayan plantation, about 4½ miles south-east of the Ata railway station, furnishes a none too successful example of sowings on uncultivated but irrigable land. This land, 162 acres in extent, was acquired in 1905, with the view mainly of providing bark for the Cawnpore tanneries. The plantation has suffered from insufficient irrigation, combined with the effects of abnormal frost and drought.

More recent experiments have been carried out on black cotton soil in the Hamirpur district in localities where the normal rainfall varies from 33 to 38 in. These experiments are interesting as showing the excellent results attainable by sowing on raised ridges both on water-logged and on over-drained ground. Under this method trenches 1½ ft. by 1½ ft. in section and 10 ft. apart are dug, and the loose earth is heaped up in a ridge alongside the trench. The seed is sown along the top of the ridge in June, before the rains commence; weeding is carried out throughout the rains, and after the rains, when the soil dries and tends to cake, it is kept loose, cracks being filled up. The seedlings are thinned out from the earliest stage; at first they are pulled up by hand, and afterwards superfluous plants are cut down with pruning shears, the rule being to thin out to such an extent as to prevent the plants from touching each other. The weeding, loosening of the soil, and thinning promote vigorous development, and by the end of the first season the young plants reach a height of 1½ to 2 ft. or more with long thick taproots and stout stems and branches. As a rule it is found that unless the plants have strongly developed side branches they are liable to dry up in the hot weather. In order to guard against frost the grass which springs up between the lines, and which intensifies the risk, is cut and sold after the end of the rains. Fig. 162 shows these ridge sowings during the cutting of the grass. The main objection to this form of sowing on continuous ridges is its high cost, which in the experimental stages amounted to Rs. 15 to Rs. 20 per acre with an additional Re. 1 for each weeding, or Rs. 6 for six weedings in the first year. It is believed, however, that the cost will be considerably reduced after further experience, and by making the ridges non-continuous, say 5 ft. lengths of ridge alternating with breaks of 5 ft. Ridge sowings have given good results in the Fisher forest at Etawah (see Fig. 163).

Other methods which have been tried in the same locality are sowing in mounds, broadcast, and in ploughed lines, pits, and patches: these have proved far less successful than ridge sowings. Mound sowings were found to be fairly successful, provided the mounds were high: they are cheaper than ridge sowings, costing Rs. 9 per 100 mounds, but when failures occur large gaps are the result. Broadcast sowings have been successful only on the higher ground, and the results are therefore patchy. The ground requires to be kept loose and the plants to be weeded and thinned, operations which are difficult under the broadcast system. Sowings in ploughed lines were likewise successful only on the higher ground, not on low ground. The lines tend to crack longitudinally after the rains, causing the death of some of the plants. Thorough weeding and thinning of the plants and loosening of the soil are

FIG. 162. *Acacia arabica*, weeded ridge sowings, end of first season, Hamirpur district, United Provinces: grass being cut between lines.

FIG. 163. *Acacia arabica*, ridge sowings in bed of stream, end of second year, Fisher forest, Etawah, United Provinces.

FIG. 164. Ravine lands being afforested with *Acacia arabica*, Kalpi, United Provinces.

FIG. 165. *Acacia arabica*, sowings on ravine lands, Kalpi, United Provinces.

necessary. Sowings in pits and patches proved an entire failure, the seedlings being swamped not long after germination.

Afforestation of ravine lands: the Kalpi plantation. The Kalpi plantation in the Jalaun district of the United Provinces was started in 1904 by the acquisition of 850 acres of ravine land, with the twofold object of producing supplies of babul bark for the Cawnpore tanneries and of ascertaining whether ravine lands could be successfully afforested with babul, in order to check the erosion to which these tracts are subject every year. Afforestation work was completed over the whole area in nine years.

This plantation may be regarded so far as purely experimental, but it has demonstrated that the ravine lands of the United Provinces can be successfully afforested with babul. The financial success of the plantation has not yet been assured, but this is due largely to the experimental character and therefore high cost of the work, and to a succession of abnormal years of frost and drought which greatly militated against success, and required the partial renewal of sowing operations over the same ground for a few years in succession. The plantation might have been more successful had closer supervision been possible, but as far as they go the results have been by no means unsatisfactory.

The preliminary work of reclamation of these ravine lands consists of breaking down the steep sides of the ravines into gentler slopes and constructing at intervals across the ravines bunds of loose earth with suitable outlets for water dug in the hard ground round their ends: these bunds are constructed at a comparatively cheap rate. This work is followed by the sowing of babul seed thickly along the bunds, on the sides of the ravines and on the elevated ground between them. The soil is extremely poor, with layers of gravel and *kankar*, the latter in particular hindering the development of the taproot. The sowings have proved particularly successful on the bunds of loose earth, which have become covered with dense promising crops of babul.

Apart from the bund sowings, which have always given the greatest success, three principal methods of sowing were tried:

1. Ploughing in strips with broadcast sowing. This was carried out in places where the ground was sufficiently level: strips were ploughed to a width of 3 or 4 ft., a distance of about four paces separating the strips, and seed was sown broadcast along the strips and covered by means of the agricultural *patra*. After the first year the width of the ploughed strips was increased to 5 or 6 ft. Ploughing was carried out at the commencement of and after the end of the monsoon rains, that is up to the middle of July and in September and October, and again during the winter rains in December and January. Thorough ploughing is necessary to eradicate the roots of grass and weeds.

2. Pitting. Where ploughing was impracticable, pits measuring $1\frac{1}{2}$ ft. in diameter and depth were dug at frequent intervals on contour lines, the loose earth being returned to the pits and the seed being sown on it: in the second year the size of the pits was reduced to 1 ft. in diameter and depth.

3. Lining. This was a modified form of pitting in which the lines consisted of elongated pits along the contour.

In each case the seed was sown at the beginning of the year, and at the end of the first season the success, particularly in the case of the sowings in ploughed strips and along contour lines, was decidedly promising. A year of abnormal frost and two years of abnormal drought, however, killed a large proportion of the young plants and seriously interfered with the success of the experiment. Indeed, throughout these sowings drought has proved the most serious source of injury, and success depends largely on years of good rainfall. The normal rainfall here is 32 in.

The sowings on the more level parts of the plantation have proved least successful, owing to the poverty and hardness of the soil, which increase the danger from drought. The whole plantation has been fenced and regularly fire-protected. The crop of grass which sprang up with the sowings necessitated careful weeding from the first season. It was sometimes found necessary to weed more than once during the first season, and the weeding was continued in subsequent years until the plants were well clear of grass and weeds. Hand-watering of the young plants was tried at one time, but had to be given up owing to its high cost. Fig. 164 shows the general aspect of the ravine lands in the Kalpi plantation, and Fig. 165 shows some of the results of the afforestation work.

More recent work in the afforestation of ravine lands in the Etawah district has given wonderfully successful results even on the most unpromising ground, where owing to the denuded and hardened condition of the soil the whole rainfall drains off rapidly. The subsoil water-level is at a great depth, and the upper strata of the soil are excessively dry. On such ground great success has been attained by deep ploughing, sowing of tree seeds in June, and repeated weeding and loosening of the soil. The first weeding is carried out soon after the first showers of rain, and two more weedings are carried out before the end of October, the soil being well loosened at the time of the last weeding. The ravines themselves are reclaimed by the construction of earth bunds at intervals across their beds, with the object of holding up silt, and the bunds and beds of silt are sown up. The sides of the ravines are afforested by means of a system of contour trenches and ridges on which sowings are carried out. Apart from *Acacia arabica* it has been found possible to raise crops of teak, *Dalbergia Sissoo*, *Gmelina arborea*, and other species on these ravine lands. The total cost of reclamation and afforestation amounts to between Rs. 50 and Rs. 60 per acre, inclusive of establishment charges and depreciation on plough bullocks and plant. The success of this work depends largely on the protection of the young plantations from grazing.

Experimental plantations on saline lands. Experimental plantations of *Acacia arabica* and *Prosopis spicigera* on salt-impregnated lands in the Aligarh district are described by Mr. G. Greig in the *Indian Forester*, vol. ix (1883), p. 454. Success was obtained by digging pits 3 to 4 ft. deep and filling them with good soil, in which young nursery-raised plants were planted. The seed was sown in the nursery early in June, the seedlings being pricked out 2 ft. apart in July, when about 4 in. high, and transplanted early in the rainy season of the following year, when about 2 ft. high, great care being taken to keep moist earth, bound on with grass, round the roots. Transplanting was

also found to be possible, if carefully done, in December and January. The plantations were regularly irrigated. Flooding was found to be injurious to the young trees; the best method of irrigation proved to be by means of small channels 1 ft. broad and 1 ft. deep running along the edges of the lines of trees, the water being allowed to stand in the channels for several hours and to percolate into the pits in which the trees were planted. Eleven acres of the Pardilnagar plantation, on strongly saline land, had been planted in this way eight or nine years previously, and some three-fourths of the area was densely covered with *Acacia arabica* trees 20 ft. or more in height.

SILVICULTURAL TREATMENT. *Clear fellings.* The system under which the babul is most commonly worked is that of clear-felling in equal annual coupes with artificial reproduction by sowing under one of the methods already described. This system is the one in vogue in Berar, the Bombay Deccan, Sind, and the United Provinces, the rotation ordinarily employed being 25 or 30 years in Berar, 30 or 40 years in the Bombay Deccan, and 30 years in Sind. Actually the rotation in Berar is two years shorter, the first two years being taken up with the cultivation of field crops prior to the sowing of babul. The tendency in Berar is to reduce the rotation, as experience has shown that after twenty years the babul is increasingly liable to fungus attacks. For the supply of tanning bark in the United Provinces a rotation of sixteen years is being adopted provisionally in afforestation schemes, though it is possible that in ravine lands it may be necessary to lengthen the rotation to twenty years. In Madras certain babul forests are worked under clear fellings, a few standards being sometimes left to provide natural reproduction.

In Sind the management is complicated by cyclones, drought, and erosion, and by the necessity for irrigation. The first three factors upset the working plans from time to time, necessitating the temporary suspension of regular fellings to provide for the removal of dead and fallen material. Special 'erosion fellings' are carried out to clear threatened banks in advance of the river's action, with the object not only of utilizing the trees but also of preventing the formation in the river of snags which endanger navigation. Irrigation schemes of considerable magnitude and complexity are also a special feature of the management of the Sind babul forests. Reproduction is not altogether artificial, a certain amount of natural reproduction being also obtainable; artificial sowings, therefore, though sometimes extensive, may be regarded as supplementary. A rotation of thirty years has been adopted primarily to meet the demand for fuel. The coupes are sold standing in August each year; the purchaser commences felling on October 1 or as soon afterwards as the floods subside, and completes felling and extraction by September 30 following, after which seed is broadcasted over the felled area.

Coppice-with-standards. In some parts of Madras, where babul of moderate size coppices without difficulty, the system of coppice-with-standards is followed; the standards left are few in number, and the coppice is usually worked on a rotation of fifteen to twenty years.

Thinnings. Practice as regards the conduct of thinnings varies in different localities. In Sind thinnings are not carried out. In Berar they are considered essential to the proper development of the crop. Regular thinnings

usually commence at an age of about ten years, and are repeated at intervals of five or six years; they are carried out with sufficient intensity to free the crowns of the trees from contact with each other. In the Bombay Deccan regular thinnings are also the rule.

Grazing. The question of closure to grazing has been carefully studied in Berar, and it is now recognized to be most beneficial to admit light grazing of cows and bullocks, one animal per 2 acres or sometimes up to one head per acre, as soon as the field crops are off the ground: this continues until the young crop is well established, that is for about five to seven years, after which the limit as to number is removed and buffaloes may also be admitted, but camels, goats, and sheep are excluded. In the Bombay Deccan closure to all kinds of grazing is prescribed for varying periods up to fifteen years or even more. In Sind the coupes are closed to all grazing for five years from the date of sowing, though in view of the rank growth of grass which springs up it would probably be beneficial to admit light grazing of cows and bullocks at an earlier stage: this is recognized, and actually closure is enforced for the first six to twelve months only. Browsers are not admitted until ten years after sowing, though it would be advantageous to exclude them for a longer period, if not permanently.

RATE OF GROWTH. The annual rings in *Acacia arabica* are indistinct, and much reliance cannot therefore be placed on the results of ring-countings. The rate of growth varies considerably, but under favourable conditions it is rapid. The following recorded measurements refer to various localities:

Punjab. Brandis[1] says that in the Punjab the tree attains a girth of 2½ ft. in about twelve years, and 5 ft. in about thirty years. Mr. Minniken reported that in the Delhi Bela plantation a girth of 2 ft. was attained in 7½ years.

Sind. Brandis[1] states that in lower and middle Sind the average girth at 4 ft. from ground-level has been ascertained to be 4 ft. in 35 years, and 6 ft. in 55 years. He also mentions that trees planted in 1844 at Jacobabad reached in less than 30 years a girth of 6–8 ft. and a height of 50–60 ft. More recent measurements in the Jerruck forest division[2] in annually inundated coupes of known age from 5 to 18 years old showed a mean annual girth increment of 1·73 in.: on alluvial land the age of which was approximately known the mean annual girth increment up to 40 years was estimated to be 1·67 in.

In the Hyderabad forest division measurements of trees of known age gave the following results:[3]

Age.	Diameter.	Corresponding girth.	
years.	in.	ft.	in.
5	1·8	0	5·6
10	3·5	0	11·0
15	5·0	1	3·7
20	6·2	1	7·5

[1] For. Flora N.-W. and Central India, p. 182.

[2] Revised Working Plan for the Jerruck Forest Division, D. J. Navani, 1915.

[3] Working Plan for the Hyderabad Forest Division, H. Mitra, 1900.

Bombay Deccan. In the Ahmednagar forest division the following has been estimated to be the average rate of growth, based on ring-countings :[1]

Acacia arabica : rate of growth, Ahmednagar.

Age. years.	Height. ft.	Diameter at base without bark. in.	Volume. cub. ft.
5	20–25	2·5	0·5
10		5·0	2·2
15	30–40	7·5	5·1
20		10·0	9·0
25	40–45	12·5	16·0
30		15·0	24·0
35	45–50	17·5	35·0
40		20·0	45·0

The following measurements are recorded in the Poona babul forest working plan,[2] though the working plan officer does not place absolute reliance on them since they are based on ring-countings :

Acacia arabica : rate of growth, Poona.

	Mean radius.			Mean radius.	
Age. years.	Above flood-level. in.	Below flood-level. in.	Age. years.	Above flood-level. in.	Below flood-level. in.
5	1·2	1·4	30	5·3	6·5
10	2·1	2·4	35	6·2	7·6
15	2·9	3·4	40	7·2	8·8
20	3·7	4·4	45	8·3	—
25	4·4	5·4	50	9·4	—

Berar. Mr. Shrinivasulu Nayadu[3] says that in Berar generally speaking a babul crop attains a height of 12 to 15 ft. in ten years, and estimates that with proper cultural attention babul crops ought to produce about 1 ton or 40 cub. ft. per acre per annum. In the Loni Bhongaon range working plan the mean annual radial increment is estimated from ring-countings to be 0·19 in., and the average yield of timber and fuel in existing coupes is estimated at 470 cub. ft. solid per acre.

Sample plot measurements extending over four years in the Akola forest division gave the following results :

Acacia arabica : rate of growth, Akola.

Plot No.	Number of trees measured.	Girths of trees measured. in.	Mean annual girth increment for 4 years. in.
1	27	30–56	2·0
2	15	16–46	1·6
3	13	15–30	0·94
4	13	15–33	0·9
5	6	24–50	1·2

[1] Working Plan for the Fuel and Fodder Reserves of the Ahmednagar Division, R. S. F. Fagan, 1901.

[2] Working Plan for the Poona Babul Forest, L. Napier, 1902.

[3] *loc. cit.*, pp. 504 and 512.

Madras. Mr. A. W. Lushington [1] records the following girth measurements, presumably excluding bark, based on ring-countings in the Guntur taluk of the Kistna district :

Age (years) . . .	10	15	20	25	30	35
Girth (inches) . .	7·1	13·9	19·4	24·9	34·1	43·2

The sapwood varied from three to six rings in thickness. He mentions elsewhere [2] that some samples gave an average of $1\frac{1}{2}$ rings per inch of radius : this rate of growth, equivalent to a mean annual girth increment of about $4\frac{1}{2}$ in., is extremely rapid. The soil is black cotton, and the normal rainfall is about 34 in.

2. **Acacia leucophloea,** Willd. Syn. *Mimosa leucophloea*, Roxb. White-barked acacia. Vern. *Reru, rinj, raunj, rhea, safed kikar*, Hind. ; *Hewar*, Mar. ; *Velvaylam*, Tam. ; *Tella tuma*, Tel. ; *Tanaung*, Burm. (Fig. 167.)

A moderate-sized to large thorny deciduous tree, with a somewhat spreading crown and a trunk often crooked and gnarled. Bark light yellowish grey to nearly white, smooth, exfoliating in irregular scales, light red inside ; bark of older trees rough and nearly black. Heartwood comparatively small, reddish brown streaked with darker and lighter colour, strong and hard. The wood, which is not of great value, is used for posts and beams, carts, wheels, agricultural implements and turning, also for fuel.

Distribution and habitat. This tree is found on the plains of the Punjab and United Provinces, particularly in the drier parts, in the Siwalik hills between the Jumna and the Ravi, Rajputana, central, western, and southern India, and Burma, chiefly in the dry zone. It is characteristic of dry regions, occurring chiefly in open scrub or thorn forests. In the Indian Peninsula it is often very common on trap and on black cotton soil, though it is also found on other geological formations. In the Deccan, the south Mahratta country, and the Central Provinces its associates vary from place to place, but include some or all of the following species: *Acacia Catechu, Zizyphus Jujuba, Z. Xylopyrus, Prosopis spicigera, Chloroxylon Swietenia, Soymida febrifuga, Diospyros Melanoxylon, Aegle Marmelos, Butea frondosa, Anogeissus latifolia, Cassia Fistula, Azadirachta indica*, and other species, while in southern India in addition to most of these it is commonly associated with *Acacia Latronum, A. eburnea, Albizzia amara, Canthium parviflorum*, and *Dolichandrone crispa.*

In the dry zone of Burma it is one of the most characteristic trees, forming somewhat open forests, often on poor shallow soil, in association with *Acacia Catechu, Terminalia Oliveri, Tectona Hamiltoniana, Zizyphus Jujuba, Limonia acidissima*, and other dry zone species.

In its natural habitat the absolute maximum shade temperature varies from 105° to 120° F., the absolute minimum from 30° to 55° F., and the normal rainfall from 18 to 60 in.

Leaf-shedding, flowering, and fruiting. The tree is leafless towards the end of the cold season and in the earlier part of the hot season, the new leaves appearing about April. The yellowish white flowers, in small globose

[1] Ind. Forester, xxi (1895), p. 255.

[2] Preliminary Working Scheme for the Guntur Babul Working Circle, Kistna District, 1893.

heads 0·25 in. in diameter, arranged in large terminal panicles, appear from August to November (sometimes May, according to Brandis); the tree is a conspicuous sight when in blossom. The pods, 4–8 in. long by 0·2–0·35 in. broad, flat, slightly curved, ripen from April to June (or earlier?). The pods are 10- to 20-seeded, and are scarcely dehiscent. The seeds (Fig. 166, *a*) are irregularly elliptical or rhomboidal, 0·2–0·25 in. by 0·15–0·2 in., dark brown, smooth, shining, compressed, with a hard testa: about 200 weigh 1 oz. The seed germinates readily with moisture and warmth, and does not require any special preparation.

GERMINATION (Fig. 166, *b–e*). Epigeous. The radicle emerges, the hypocotyl elongating with slight arching and carrying the cotyledons above ground; the testa usually remains partially enclosing the cotyledons until they expand, when it falls to the ground.

THE SEEDLING (Fig. 166).

Roots: primary root long, terete, tapering, wiry, white turning yellowish brown: lateral roots fairly numerous, fine, fibrous: nodules present. *Hypocotyl* distinct from root, 0·4–1·5 in. long, terete, tapering slightly upwards, expanded in a ring at the base, white turning green, glabrous. *Cotyledons*: petiole 0·1 in. long or less, glabrous: lamina 0·3–0·4 in. by 0·25–0·35 in., plano-convex, somewhat fleshy, ovate obovate or oblong, apex rounded, base broadly sagittate, entire, glabrous, bright green above, paler beneath. *Stem* erect, somewhat zigzag at the nodes, wiry, glabrous, green turning brown; internodes 0·3–1·2 in. long. *Leaves* alternate. Stipular spines 0·1–0·2 in. long. First leaf once-paripinnate, rachis 0·5–0·7 in. long, terminating in a fine bristle, leaflets 4–8, usually six pairs, sub-sessile, 0·1–0·25 in. by 0·1 in. or less, obliquely oblong, entire, glabrous, mucronate; next six or more leaves bipinnate with one pair of pinnae and 5–15 leaflets on each pinna; subsequent leaves with two pairs, followed in the second season by leaves with three or four pairs of pinnae.

In loose fertile soil the growth of the seedling is fairly rapid, a height of 2 ft. or more being attained by the end of the first season. Under usual natural conditions in poor dry soil, however, the young plant grows slowly. A long taproot is developed early, and may reach a length of 1 ft. in the first month. Loose deep soil is very favourable to its development, and stiff clay is prejudicial. The seedling is sensitive to suppression by weeds: it is also very tender to frost, but has good power of recovery when killed back. Seedlings raised at Dehra Dun ceased growing by November–December, and new growth commenced in February–March.

SILVICULTURAL CHARACTERS. *Acacia leucophloea* is a decided light-demander. It stands drought well, and was not affected by the abnormal drought of 1899–1900 in the Indian Peninsula. Though young seedlings are sensitive to frost the tree itself is frost-hardy within its habitat: in the severe frost of 1910–11 in the Central Provinces it proved to be one of the hardiest of the indigenous trees. It suffers from browsing, goats in particular being very partial to it. It coppices well and produces root-suckers.

ARTIFICIAL REPRODUCTION. Experiments at Dehra Dun showed that direct sowing is more successful than transplanting. Young seedlings were found to transplant fairly well early in the first rainy season, but the transplanting checked their growth. Line sowings were found to be the most successful, as it is necessary to weed regularly, and this can be done most

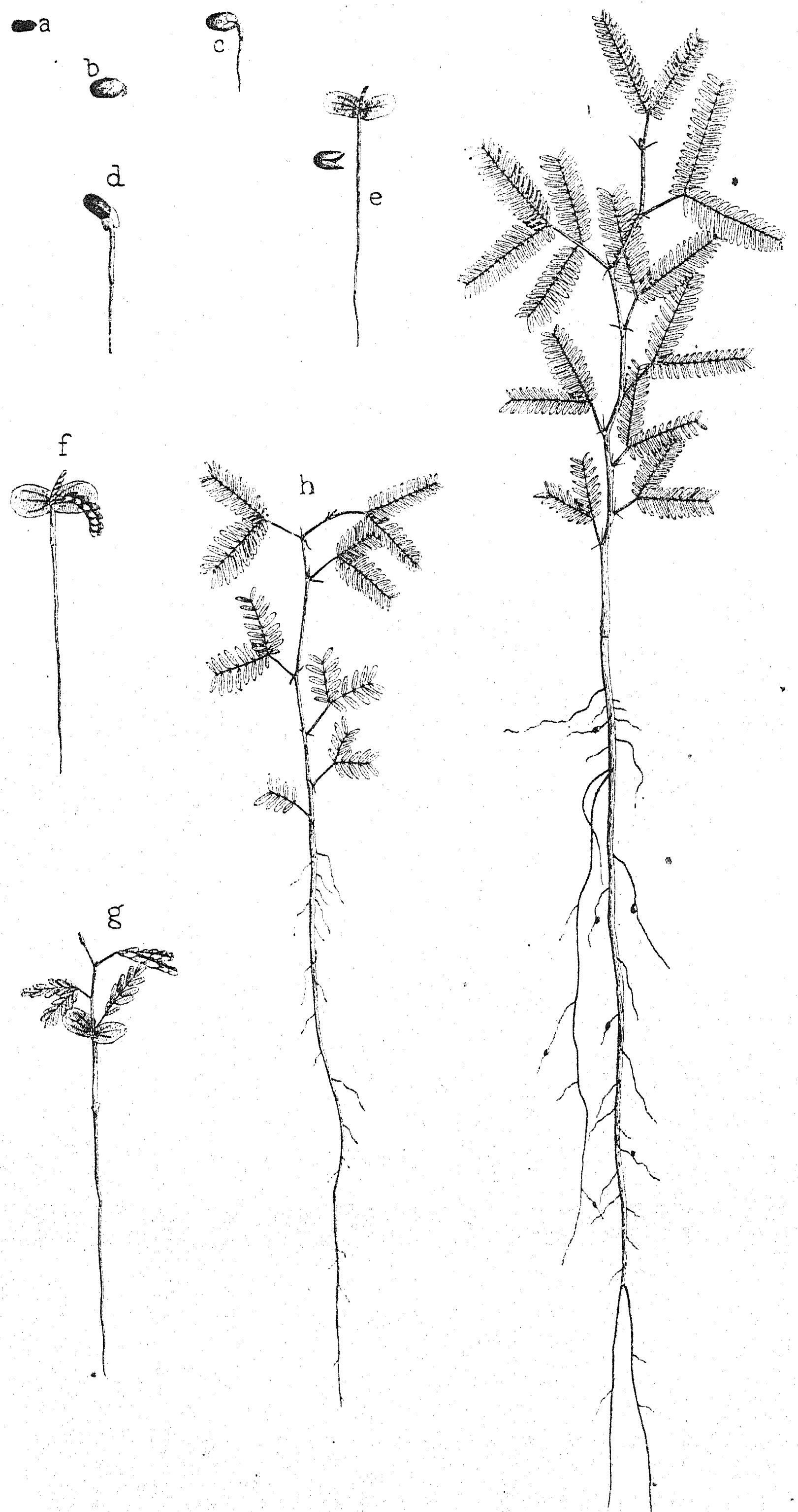

FIG. 166. *Acacia leucophloea.* Seedling × ½.

a, seed ; *b–e*, germination stages ; *f–i*, development of seedling during first season.

effectively along lines. Sowings have given good results in Ajmer-Merwara in places where the soil was not too dry. Line sowings in conjunction with the raising of field crops have been tried experimentally in Berar, and this system would appear to be the most satisfactory one to adopt: the details of this form of sowing are given on p. 435, under *Acacia arabica*.

Rate of growth. Reliable statistics of rate of growth are wanting. The tree is generally considered to be slow growing. A section 2 ft. 5 in. in girth, including bark, in the silvicultural museum at Dehra Dun had 31 rings, giving a mean annual girth increment of 0·94 in.

3. **Acacia Catechu,** Willd. Cutch tree. Syn. *A. Sundra*, DC.; *Mimosa Catechu*, Linn. Vern. *Khair*, Hind., Mar.; *Kagli, shemi*, Kan.; *Karangalli*, Tam.; *Sundra, tella tumma*, Tel.; *Sha*, Burm.

A moderate-sized deciduous tree with a light feathery crown, the branchlets armed with twin hooked prickles. Bark 0·4–0·5 in. thick, dark grey or greyish brown, rough, exfoliating in long narrow strips, brown and red inside. Sapwood yellowish white; heartwood dark or light red, very hard and durable. The wood is largely used for house-posts, agricultural implements, wheels, tool-handles, and other purposes: it also gives excellent fuel and charcoal. The substances cutch and *kath* are obtained by boiling down chips of the heartwood: the former is largely exported for dyeing and tanning, and the latter is used for chewing with betel-nut. The tree sometimes reaches a fair size: Fig. 168 shows one 10 ft. 6 in. in girth. Prain[1] distinguishes three varieties:

(1) Var. *Catechu* proper. Calyx, petals, and rachis covered with spreading hairs. Chiefly in the Punjab, Garhwal and Kumaun, Bihar, Ganjam, and in the Irrawaddy valley: also in North Kanara and the Konkan (Talbot).

(2) Var. *catechuoides*. Calyx and petals glabrous, rachis puberulous. Chiefly in the Sikkim *tarai* and Assam, also in Upper Burma, Mysore, and the Nilgiris.

(3) Var. *Sundra*. Calyx, petals, and rachis all glabrous. Chiefly in the Indian Peninsula and Upper Burma.

Distribution and habitat. Throughout the greater part of India and Burma, except in the most humid regions. The tree is most typically found in one of two main classes of forest: (1) in the shingly or sandy alluvial beds of rivers and streams which may or may not be dry for a considerable portion of the year; here it is markedly gregarious, often forming entirely pure forests: (2) in dry types of forest on high land away from watercourses, where it is frequently more or less gregarious, though commonly mixed with other species characteristic of dry regions. Examples of forest types in different localities are given below, and it will be seen that although the tree is capable of growing on the poorest soil in dry localities, it occurs also in mixed forest of good quality—as in the drier types of teak forest in Burma—where it may attain considerable dimensions.

Rock and soil. Acacia Catechu occurs on a variety of geological formations and soils, though it undoubtedly thrives best on porous alluvium composed of sand and shingle and on well-drained sandstone, as in the Pegu Yoma. It is known to occur on granite, gneiss, schist, quartzite, shale, basalt, trap,

[1] Journ. As. Soc. Bengal, LXVI, ii (1898), p. 508.

limestone, conglomerate, and laterite, while as regards soil it is common on sandy and gravelly alluvium, and on loam or gravel with varying proportions of sand and clay ; it grows also on black cotton soil. It is frequent on arid shallow stony soil and grows even on sheet rock. In the poor shallow soils composed of *murram* or *kankar*, which are frequent in parts of the Indian Peninsula, it grows where few other species are able to survive ; this adaptability is seen also in parts of the sub-Himalayan tract, where it grows pure, though in stunted form, on poor hard soil composed largely of calcareous nodules, where hardly any other tree can exist. On stiff clay where the drainage is bad it becomes stunted and tends to die off early.

Climate. Acacia Catechu is essentially a tree of comparatively dry regions, though in its alluvial form it extends into regions of heavy rainfall, as in the eastern sub-Himalayan tract, where it is found in places where the rainfall is as much as 150 in. In gravelly riverain tracts, however, it has few competitors and is no doubt enabled to establish itself for that reason. Away from riverain tracts it occurs ordinarily in localities where the normal rainfall varies from 20 to 85 in. In its natural habitat the absolute maximum shade temperature varies from 105° to 120° F., and the absolute minimum from 30° to 55° F.

Local occurrence. Sub-Himalayan tract. Acacia Catechu is common throughout the sub-Himalayan tract from the Indus to Assam, ascending the Himalayan valleys to 3,000 ft. and sometimes to 4,000 ft. From the Jumna eastwards it occurs either gregariously in the beds of rivers and streams or in various types of dry mixed forest, where it may be either more or less gregarious or scattered. The riverain *khair* forests of northern India are very characteristic. They spring up on new alluvium along the banks or in the beds of the rivers and streams in the valleys of the outer Himalaya and the Siwalik range, on deposits of sand, shingle, and boulders, extending some distance out into the plains provided the alluvium remains sandy or shingly and does not reach the consistency of soft mud. In these alluvial forests the *khair* is either pure or mixed with *Dalbergia Sissoo*, and occasionally with *Acacia eburnea*, *Bombax malabaricum*, *Albizzia procera*, and a few other species. It is also associated with characteristic grasses, the chief of which are *Saccharum Munja*, *S. spontaneum* (xerophilous form), *Aristida cyanantha*, *Triraphis madagascariensis*, and *Andropogon monticola*. There is often a dense undergrowth of *Adhatoda Vasica* in these riverain forests. The gregarious habit of the tree in this type of forest is shown in Fig. 169.

At the higher elevations it meets the hill species ; for example, above Ratighat in the Naini Tal hills, at 4,000 ft., it grows in a river-bed with *Quercus incana* and *Pinus longifolia* growing on the slopes down to the edge of the river : in the same locality it is found mixed with *Celtis australis* on old riverain boulder beds.

In non-riverain tracts the tree occurs either in scattered savannah lands or in various types of dry mixed forest, sometimes as a survival from former riverain forest which has become elevated at no very distant date above the river-bed owing to changes in the course of the river, but frequently on land, both flat and hilly, which shows no such recent transition, or on which it has sprung up naturally after the land has ceased to be new alluvium. In such

FIG. 167. *Acacia leucophloea*, Upper Burma.

FIG. 168. *Acacia Catechu* tree, 10 ft. 6 in. in girth, in riverain tract, Siwaliks, United Provinces.

Fig. 169. Riverain forest of *Acacia Catechu*, Siwaliks, United Provinces: the tall grass is *Saccharum Munja*.

tracts the *khair* is frequently mixed with a variety of deciduous species, such as *Dalbergia Sissoo*, *Bombax malabaricum*, *Garuga pinnata*, *Odina Wodier*, *Ehretia laevis*, *Phyllanthus Emblica*, *Zizyphus Jujuba*, *Bauhinia racemosa*, *Holarrhena antidysenterica*, and others. On drier and poorer ground it is stunted, but survives under conditions which are unfavourable to the existence of almost every other species. Striking examples of its hardiness occur in certain parts of the submontane mixed forests of the Gonda district in the United Provinces, on undulating ground intersected by ravines; the soil, besides being very poor, is subject to erosion, which is hastened by grazing, and the roots of the trees are in consequence much exposed, as shown in Fig. 172. In the poorest parts of these tracts *Acacia Catechu* occurs pure, nothing else being capable of growing, but where the soil is somewhat more favourable it is associated with stunted specimens of *Diospyros tomentosa*, *Anogeissus latifolia*, *Buchanania latifolia*, and *Nyctanthes Arbor-tristis*. The soil, which is excessively poor, is a reddish clay with calcareous nodular pebbles.

West of the Jumna the riverain type of *khair* forest is scarce, being confined to a few localities, for example in parts of the Kangra valley, but the tree is common on the dry foot-hills, often associated with *A. modesta*, and extends in some places into the region of *Pinus longifolia*.

In the sub-Himalayan tract *Acacia Catechu* occurs in localities where the normal rainfall varies from 25 to 180 in.

Indian Peninsula. The tree is common throughout the greater part of the Indian Peninsula in dry types of mixed forest on a variety of geological formations and soils.

In the Central Provinces and elsewhere it occurs in open grass-lands, and in teak forest of a dry type as well as in forest devoid of teak, its commoner associates being *Terminalia tomentosa*, *T. Chebula*, *Lagerstroemia parviflora*, *Anogeissus latifolia*, *Diospyros Melanoxylon*, *Ougeinia dalbergioides*, *Buchanania latifolia*, *Zizyphus Jujuba*, *Z. Xylopyrus*, *Aegle Marmelos*, *Odina Wodier*, *Butea frondosa*, *Acacia leucophloea*, *Cochlospermum Gossypium*, *Holarrhena antidysenterica*, *Phyllanthus Emblica*, *Chloroxylon Swietenia*, *Soymida febrifuga*, *Cleistanthus collinus*, *Gardenia latifolia*, *G. lucida*, and other trees, as well as the bamboo *Dendrocalamus strictus*. On dry hills it is found with *Boswellia serrata* and *Sterculia urens*, in places where the soil is poor and shallow, with sheet rock cropping out. It is also found associated with *Hardwickia binata* on trap or on gravelly soil. In the Central Provinces it is one of the commonest species in a poor stunted type of forest where the soil has an excess of calcareous nodules on the surface, its chief associates here being *Chloroxylon Swietenia*, *Soymida febrifuga*, *Diospyros Melanoxylon*, *Buchanania latifolia*, and *Terminalia tomentosa*.

In Bombay it occurs in Guzerat, the Deccan, and the South Mahratta country in dry open thorn forests. It is associated with many of the species already named as well as with *Prosopis spicigera* and sometimes *Acacia arabica*; here also it forms poor stunted types of forest on dry calcareous or *murram* soil. Talbot says that it ascends to 3,700 ft. in the Khandesh Akrani, and that it occurs nearly pure in larger or smaller patches on the low level laterite near the sea-coast in North Kanara and the Konkan. In the Dangs of Surat

it is common, but not so plentiful as it once was, having been heavily worked at one time for catechu boiling.

In Chota Nagpur it is found not only in dry mixed deciduous forest but also frequently in association with sal. It occurs in the dry forests of Central India and Rajputana, often growing on mere sheet rock in the hilly tracts. It is common in Merwara associated with *Anogeissus pendula*, *Albizzia odoratissima*, *Boswellia serrata*, *Acacia leucophloea*, and other species.

In Madras it is common in dry mixed forests, often on dry stony soil, associated with *Acacia leucophloea*, *Albizzia amara*, *A. odoratissima*, *Chloroxylon Swietenia*, *Prosopis spicigera*, *Cassia Fistula*, *Anogeissus latifolia*, *Zizyphus Jujuba*, *Z. Xylopyrus*, *Santalum album*, *Hardwickia binata*, and others.

Burma. *Acacia Catechu* is one of the commonest trees in the dry zone of Upper Burma, where it occurs partly in the form of pure crops in the sandy beds of streams and partly on dry ground away from rivers and streams. The riverain cutch attains fairly large dimensions, but the trees on the higher ground are often stunted, forming scrub forests in association with *Acacia leucophloea*, *Terminalia Oliveri*, *T. tomentosa*, *Tectona Hamiltoniana*, *Capparis burmanica*, *C. flavicans*, *Cassia renigera*, *Bauhinia racemosa*, *Zizyphus Jujuba*, *Azadirachta indica*, *Diospyros burmanica*, *Limonia acidissima*, *Flacourtia cataphracta*, *Gardenia turgida*, *Phyllanthus Emblica*, *Pentacme suavis*, and occasionally *Dipterocarpus tuberculatus*. In this dry region, where the rainfall varies from about 23 to 40 in. and the soil is often poor and shallow, the trees are for the most part of small size and the crop is open. Cutch trees were formerly more plentiful than they are now, but have been extensively cut out for cutch boiling, not only the stems but also the stumps and main roots having been utilized for this purpose.

In Burma the tree extends well outside the dry zone proper, occurring both in Upper and in Lower Burma and in the Shan States in mixed deciduous forests with or without teak, in association with *Terminalia tomentosa*, *T. Chebula*, *Xylia dolabriformis*, *Homalium tomentosum*, *Pterocarpus macrocarpus*, *Dalbergia cultrata*, *Pentacme suavis*, *Shorea obtusa*, and many other species characteristic of the drier types of the upper mixed forest. Bamboos are also common, the chief being *Dendrocalamus strictus*, *Bambusa Tulda*, and *Cephalostachyum pergracile*. In the Pegu Yoma the tree extends southward to the northern part of the Tharrawaddy district, where on the well-drained sandstones and shales of this range it attains large dimensions, the minimum felling diameter under the Taungnyo working plan being fixed at 1 ft. 6 in. In the Thayetmyo forest division (East Yoma and other reserves) the exploitable girth is fixed at $4\frac{1}{2}$ ft. In Burma it does not extend into regions with a rainfall higher than 65 in.

LEAF-SHEDDING, FLOWERING, AND FRUITING. The tree is leafless for a time during the hot season. In northern India the leaves are shed about February, the new leaves appearing towards the end of April or during May. When leafless the *khair* forests have a grey and dreary appearance, in strong contrast to the fresh green of the sissoo crops, which by that time have come into new leaf. By June, however, the *khair* forests have acquired their new delicate green feathery foliage, and are a beautiful sight. The whitish flowering spikes, 2–3·5 in. long, which are axillary on the young shoots, appear with the new

FIG. 170. *Acacia Catechu*—SEEDLING × ½

a—Fruit b—Seed c - g—Germination stages h - j—Early development of seedling, first season
k—Seedling towards end of second season

leaves, and add to the beauty of the trees. The trees continue in flower until July or August, sometimes later. The pods develop rapidly, becoming full-sized by September or October, and turning from green to reddish green and then to brown: they begin to ripen by the end of November and continue ripening during December and early January. The pods (Fig. 170, *a*) are 2–4 in. long by 0·4–0·6 in. broad, straight, flat, dark brown, shining, dehiscent, usually three- to six-seeded. The seeds (Fig. 170, *b*) are 0·25–0·35 in. by 0·2–0·3 in., broadly ovate or orbicular, dark greenish brown, smooth, shining, moderately hard, with a hard testa which becomes soft and pliant on soaking. About 900–1,100 seeds weigh 1 oz.

The pods dehisce not long after ripening, and commence falling in January, continuing to fall in the succeeding months: the seeds adhere to the pod valves, and the latter being light are often blown to a considerable distance from the trees, dissemination of the seed being effected in this way. In alluvial tracts the dissemination of the seed is further effected by water. Some pods remain on the tree until the following October, by which time, however, the seed has become so damaged by insects as to be useless.

As a rule the tree seeds well every year. The seed can best be collected by stripping the pods off the trees in December or early January and spreading them in the sun for a few days. The seeds cling tenaciously to the pod valves, and in order to detach them it is necessary to heap the pods on a large cloth and beat them well with sticks, after which the seeds can be separated by shaking and winnowing in a flat basket.

The seed is badly subject to insect attacks, even when carefully stored. Seed kept for one year was tested at Dehra Dun and found to be quite unfertile: it is not certain how far this was due to insect attacks. It is advisable, therefore, to sow the seed the year in which it is collected. The fertility of fresh undamaged seed is high. The seed germinates readily with moderate rain, and requires no special preparation to stimulate germination.

Germination (Fig. 170, *c–g*). Epigeous. The radicle emerges first and curves downwards; the hypocotyl then elongates, with or without arching, and raises above ground the cotyledons enveloped by the testa. The cotyledons expand, turning from yellow to pale green, and the testa falls to the ground.

The seedling (Fig. 170).

Roots: primary root long, wiry, thickening considerably after a few months, terete, tapering, whitish or pale brown becoming darker brown: lateral roots few to numerous, short, fibrous or wiry, distributed down main root: nodules present. *Hypocotyl* distinct from root, 0·5–0·8 in. long, terete, expanded in a ring at the base, white becoming green, glabrous or sparsely pubescent in upper part. *Cotyledons* very shortly petiolate, plano-convex, somewhat fleshy, 0·3–0·4 in. in diameter, orbicular, entire, base sagittate, glabrous, yellow becoming green, obscurely 3-veined. *Stem* erect, somewhat zigzag at the nodes, thin, delicate at first, becoming wiry, green or reddish, young parts pubescent, elsewhere glabrous or nearly so. *Leaves* alternate. Stipules minute, subulate, caducous. First leaf once paripinnate with three to four pairs of opposite leaflets 0·2–0·25 in. by 0·1 in., rachis pubescent; subsequent leaves bipinnate, at first with one pair, then with two pairs of pinnae, each pinna at first with 3–5 pairs of leaflets, the number increasing with succeeding leaves, leaflets 0·2–0·4 in. by 0·1–0·2 in.; the number of pinnae increases in subsequent leaves.

Under favourable conditions the growth of the seedling is rapid from the commencement, plants regularly weeded and watered attaining a height of 3 ft. or more in three months from germination. Branching takes place at an early age, and the general habit is more or less straggling. The seedling develops a long taproot, which may attain a length of 2 ft. or more in three months.

Under natural conditions the growth of the seedlings may be extremely slow, particularly if they are hampered by weeds or subject to damage by grazing. Thus a plot of natural seedlings 200 sq. ft. in area on sand and shingle among scattered tufts of grass about 3 ft. high in a dry river-bed in the Siwaliks was kept under observation for about 4½ years: the following shows the number of seedlings counted and their maximum height at different stages:

Date of observation.	No. of seedlings present.	Maximum height of seedlings.	
		ft.	in.
December 11, 1910 (end of 1st season) . . .	201	0	6
December 28, 1911 (end of 2nd season) . .	—	1	0
December 19, 1913 (end of 4th season) . . .	74	0	11
April 14, 1915 (beginning of 6th season) . .	24	0	10

These results show a steady diminution in the number of seedlings and no progress in their growth, this being due mainly to damage by grazing; nearly all the survivors were found in the clumps of grass, where they received a certain amount of protection.

The beneficial results of irrigation and weeding, of which the latter is of even more importance than the former, are well demonstrated by the following figures showing the development of seedlings in various experimental plots at Dehra Dun:

Acacia Catechu: development of seedlings under varying treatment.

Time of observation.	Irrigated.		Unirrigated.							
	Regularly weeded.	Not weeded.	Regularly weeded.				Not weeded.			
					ft.	in.			ft.	in.
End of 1st season	Maximum height 5 ft. 2 in. (very vigorous)	Maximum height 5 in. (weakly)	(1)	Maximum height (fairly vigorous)	0	8	(1)	Maximum height (very weakly)	0	5
			(2)	,, ,,	3	8	(2)	,, ,,	0	6
			(3)	,, ,,	2	3	(3)	,, ,,	0	6
End of 2nd season	Maximum height 10 ft. 3 in. (very vigorous)	Maximum height 1 ft. 0 in.	(1)	,, ,,	4	0	(1)	,, ,,	0	7
			(2)	,, ,,	6	3	(2)	,, ,,	1.	5
			(3)	,, ,,	12	9	(3)	,, ,,	1	10
			(4)	,, ,,	12	0	(4)	,, ,,	1	2
			(5)	,, ,,	10	0	(5)	,, ,,	2	3
End of 3rd season	Maximum height 14 ft. 0 in. (very vigorous)	Maximum height 1 ft. 1 in.	(1)	,, ,,	9	6	(1)	Height 2 ft. 6 in. to 7 ft.: thin lanky stems among growth of weeds		
			(2)	Maximum height	18	8				
				Mean height	8	4				
				Maximum girth	0	7				
			(3)	Maximum height	14	10				
			(4)	Maximum height	17	9				
				Mean height	6	0				
				Maximum girth	0	7½				

In most of the unweeded plots the seedlings were all killed out by suppression or had damped off before the end of the third season. One of the commonest forms of mortality in the case of seedlings in a heavy growth of weeds is the

damping off to which they are subject during the rains: in tall open grass, however, where they are not subjected to such a degree of damp, they are capable of making their way up successfully, though their development is comparatively slow during the process.

The effect of light on the development of the seedling has been studied at Dehra Dun in the case of plants grown in plots under varying degrees of shade: these tests proved the seedlings to be strongly light-demanding, and liable to be killed out in one season where the shade is at all dense. The seedlings are frost-tender during the first few years, and are also apt to suffer from drought during long periods of dry weather. In dry regions they sometimes die back for a few years in succession, eventually shooting up after the root has established itself. Rats do much injury to the seedlings by gnawing through the taproots. The power of recovery of the plants, however, is good, numerous cases having been observed of new shoots being sent up from the portions of the taproots left in the ground after this form of damage. Similar new shoots were found to be sent up from the roots in the case of plants thinned out in unirrigated line sowings at Dehra Dun, in which the taproots were severed a few inches below ground-level. Young plants are very subject to browsing by deer.

Silvicultural characters. *Acacia Catechu* is a strong light-demander. Within its habitat it is decidedly frost-hardy, though young seedlings are somewhat tender: in the abnormal frost of 1905 in northern India it stood the frost better than most species, though young coppice growth was killed back. It is often found thriving in frosty grass-lands where tender species succumb. Although decidedly xerophilous in character, and capable of growing in dry situations where almost every other species fails to survive, it may suffer severely in years of abnormal drought, as in 1899–1900 and subsequently in the Indian Peninsula, and in 1914–15 in Palamau, Chota Nagpur. In the abnormal drought of 1907 and 1908 in Oudh it was unaffected on the low alluvial lands where it grows.

The tree coppices well up to a moderate size and produces root-suckers, particularly where the roots have been exposed: coppice-shoots, however, require complete light for their development, and under shade they are frequently not produced at all, the stools dying off. It is very subject to damage by browsing, and responds readily to closure to grazing. Porcupines are particularly destructive to the trees, gnawing the bark off round their bases and often killing them. Ranger Basti Ram [1] reports that he has found a smearing of lime efficacious in keeping them off. An American plan for dealing with porcupines is to soak small boards in brine and strychnine and nail them to the bases of the trees; the porcupines have a partiality for salt and gnaw the boards, dying of strychnine poisoning.

In the mixed forests *Acacia Catechu* is subject to the usual damage from climbers. In the sub-Himalayan alluvial forests a very characteristic climber is *Dregea volubilis*, which does great damage; other common climbers in these forests are *Cryptolepis Buchanani* and *Vallaris Heynei*.

Natural reproduction. Under natural conditions the seed is disseminated by wind, the seeds adhering to the light pod-valves; in alluvial

[1] Ind. Forester, xli (1915), p. 383.

tracts water is also an important agency. Germination takes place early in the rainy season, and the early development of the seedling is greatly favoured on loose soil free from weeds. Thus on alluvial sand or gravel countless numbers of small seedlings may be found in the early part of the rainy season, not only in the open, but also under comparatively dense cover. In the latter case they die rapidly owing mainly to shade and to damping off, and by the end of the season hardly a seedling is to be found. In the open a fair proportion survive provided they are protected from grazing: frequently, however, there is high mortality from drought, particularly if the soil is stiff or shallow and the roots have difficulty in penetrating it. The seed germinates readily with heavy rain, and although germination takes place ordinarily at the commencement of the monsoon it may begin earlier in the season if abnormal falls of rain occur; when this happens the seedlings almost invariably die off or the germinating seed perishes in the ensuing spell of dry weather. Such mortality is particularly marked in the case of seeds germinating on the surface of the ground. Experiments at Dehra Dun showed that this early germination takes place more readily on ground exposed to the sun than in shady places, owing to the greater warmth in the former case. In alluvial riverain situations the tufts of grass which frequently appear on new ground, provided they are not too dense, act as a useful protection from drought in the early stages. In wet and sodden grass, however, the seedlings damp off.

The adverse effects of grazing have been alluded to above, under 'the seedling', in the case of a riverain plot in the Siwaliks. A striking example of the benefits of closure to grazing came under my notice in the submontane mixed forests of the Gonda district, United Provinces, along a central fireline which separated a block of forest permanently closed to grazing from an adjoining block open to grazing. The forest on either side of the line was similar, except that on the side closed to grazing *khair* trees of all sizes filled up every gap, while on the side open to grazing this species was represented by only a few old trees. In one part the grazed forest consisted of a rather open growth of nearly pure *bael* (*Aegle Marmelos*), while on the opposite side of the line the forest closed to grazing consisted of a dense crop of *khair* with *bael* trees scattered through it. Numerous other instances might be quoted of the adverse effects of grazing on the natural reproduction of *Acacia Catechu*, but the above will suffice.

Forest Ranger A. K. Desai[1] remarks on the large quantity of *khair* reproduction which appeared in gaps formed by the heavy exploitation of trees killed by the abnormal drought of 1899–1900 in the Godhra range of the Panch Mahals, Bombay, this reproduction being stimulated by the admission of light and warmth, and no doubt also by the breaking up of the soil during the extraction of the timber.

The freedom with which natural reproduction springs up in alluvial riverain tracts is remarkable. The chief factors favouring it in such localities are the new loose soil free from heavy weeds and the abundance of light, while the soil moisture obtained by percolation no doubt also assists the development of the seedlings. As the crops become older and elevated above the river-bed through changes in the course of the river, the conditions for natural repro-

[1] Ind. Forester, xxxiv (1908), p. 15.

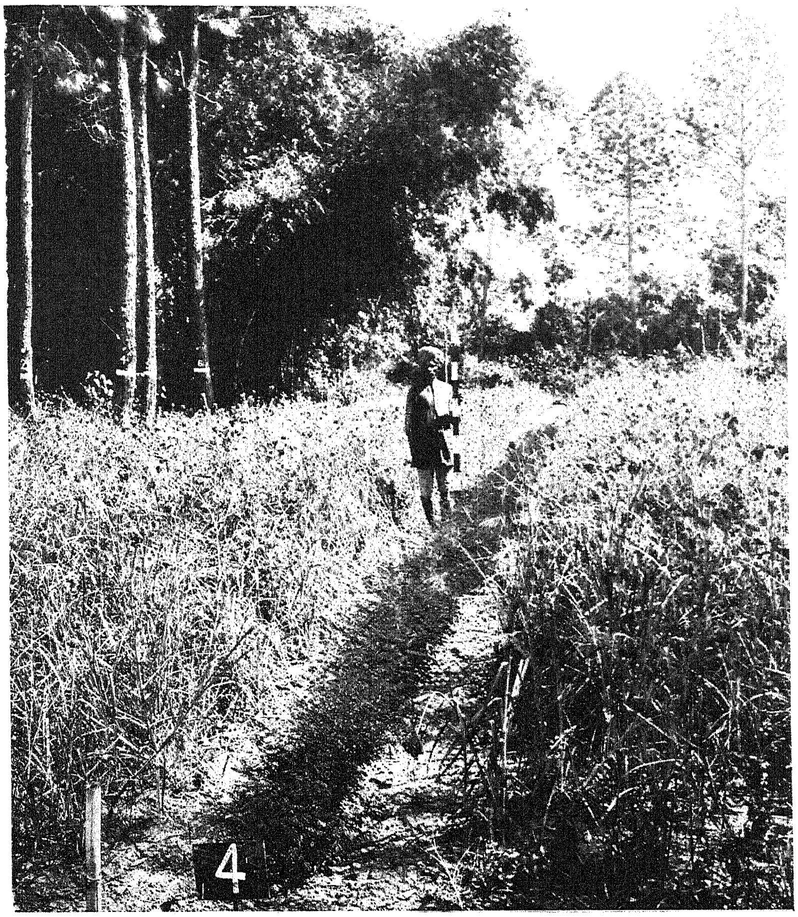

FIG. 171. Line sowings of *Acacia Catechu* $3\frac{1}{2}$ months old in conjunction with field crops, Dehra Dun.

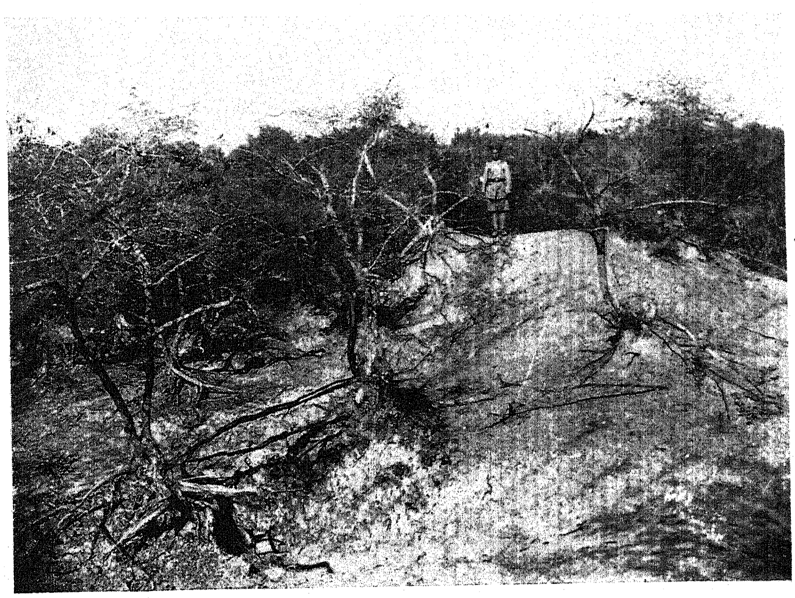

FIG. 172. *Acacia Catechu* on very poor eroded ground, Gonda district, United Provinces.

Fig. 173. *Acacia Catechu,* unirrigated line sowings, weeded and thinned, end of third season, Dehra Dun ; maximum height 18 ft. 8 in., maximum girth 7 in.

duction change. The ground becomes harder and a dense undergrowth of *Adhatoda Vasica* or other plants frequently makes its appearance. Under such conditions natural reproduction is no longer possible, and although it continues to take place where new alluvium is thrown up it ceases under the old crops.

ARTIFICIAL REPRODUCTION. Numerous experiments in the artificial reproduction of *Acacia Catechu* have been carried out at Dehra Dun. These have shown that transplanting cannot be relied on, but that direct sowing, if carried out properly, is highly successful. Transplanting was tried under different conditions, both in the first and in the second season, and moderate success was attained only by transplanting young plants early in the first rainy season, care being taken to avoid any injury to the root-system. This, however, does not appear to be the experience everywhere, for Mr. Pearson [1] says regarding this species in Bombay: 'The only results at all favourable with *khair* are those when carried out with large plants.' In the Dehra Dun experiments pruning of the roots and stem invariably resulted in the death of the seedling.

The success of direct sowings depends on: (1) the degree to which the soil is kept loose for the first two years or so after sowing; (2) thorough weeding; (3) abundance of light from the commencement. In addition the thinning out of the young plants has a marked effect on their development. Irrigation undoubtedly stimulates the growth of the plants, but is not essential provided regular loosening of the soil is carried out.

In the Dehra Dun experiments the greatest success was attained by line sowings, particularly in combination with the raising of field crops. A distance of 8 to 10 ft. between the lines should be sufficient. It was found necessary to sow the *khair* seed along the lines in clear strips 2 to 3 ft. wide, the field crops being sown in the intervening spaces (see Fig. 171). Where the crops were sown continuously over the area many of the seedlings were killed by suppression, the development of the survivors was poor and the stocking was incomplete, while the sudden exposure when the crops were reaped caused the leaves of the seedlings to fall prematurely and many of the seedlings to die down partially. The field crop employed was the lesser millet or *mandwa* (*Eleusine coracana*), which was sown in May or June and reaped in October: the land was cleared forest land, and the millet crop was dense and heavy and up to $3\frac{1}{2}$ ft. in height. The *khair* seed was sown at the same time as the millet, and the lines were kept weeded both when the crops were on the ground and after they were reaped. The results along the weeded lines were admirable, the seedlings being plentiful and vigorous and attaining a maximum height of 2 ft. 3 in. by the end of the first season and 6 ft. 3 in., with an average of 4 ft. 3 in., by the end of the second season. Regular thinning of plants, commencing from the end of the first season, stimulated their development greatly. The necessity for regular weeding may be realized from the fact that one line was left unweeded after the reaping of the crop, with the result that by the end of the next season every seedling had been killed by weeds.

In the Dehra Dun experiments, weeded line sowings without field crops also proved highly successful where the soil was thoroughly loosened before

[1] Ind. Forester, xxxi (1905), p. 638.

sowing, and regular weeding, thinning, and loosening of the soil were carried out subsequently: 1 lb. of seed was found sufficient for about 350 ft. length of line. Fig. 173 shows line sowings at the end of the third season.

Sowings of *Acacia Catechu* have been carried out in many parts of India and Burma in a variety of ways. In the grassy savannahs of Oudh line sowings have proved successful in spite of a fairly tall growth of grass in the rains. In Berar line sowings in conjunction with field crops have also done well: the system employed has been described under *Acacia arabica* (p. 435).

Mound and ridge sowings have been carried out with varying success. Owing to their high cost, however, they are hardly justified except on very stiff soil where the drainage is bad. Broadcast sowing has also been frequently tried, often with success: where suppression from weeds is to be feared, however, it cannot compare with line sowings.

In Burma numerous cutch plantations have been formed on the *taungya* system, the seed being dibbled 6 ft. by 6 ft. or 12 ft. by 3 ft. or 9 ft. by 4 ft. on temporary forest clearings in which field crops, usually hill rice, are raised. In many cases mixed plantations of teak and cutch have been formed in this way. The two species, however, do not mix well, their requirements being dissimilar; not only does the cutch damage the teak by contact with it, but one of the species in time usually ousts the other, the cutch or the teak gaining the upper hand according to the nature of the locality. These mixed plantations are not as a rule formed now. A description of these *taungya* plantations is given under *Tectona grandis*.

Silvicultural treatment. Under existing working plans the tree is frequently worked under coppice or coppice-with-standards, both in alluvial tracts and in mixed forests. The *khair* and sissoo forests of the Ganges islands, for example, are worked as simple coppice on a rotation of twenty years, a protective belt at least 100 ft. wide being left uncut round the edges of the islands. Provided the trees coppiced are not too old, and provided the standards are not numerous enough to suppress the coppice, this system has usually answered satisfactorily for the production of poles.

The treatment under high forest is a more difficult matter. Several working plans, both in India and in Burma, prescribe selection fellings, the object of which is to remove mature trees. This, however, does not ensure reproduction, which cannot be obtained under any system which does not involve removal of the overwood and of weed-growth. This being so, as far as experience goes the only system under which complete regeneration can be ensured on a given area appears to be that of clear felling with artificial reproduction. The question of regenerating riverain crops of *Dalbergia Sissoo* has been discussed in some detail on p. 314. The system proposed is to divide these crops into two classes, stable and unstable, the former to be regenerated artificially, while in the latter the fellings would consist of utilizing marketable material, regeneration being left to the vagaries of the river. For riverain crops of *Acacia Catechu* exactly the same procedure is indicated.

In crops of *Acacia Catechu* which tend to become very dense, regular thinnings are of great importance.

Rate of growth. *Coppice.* Statistics relating to coppice growth are

scanty. Measurements in Bhandara, Central Provinces, in 1912–13 showed the average height of coppice-shoots one year old to be 6 ft. 4 in. as against 7 ft. 1 in. for teak and 6 ft. 6 in. for *Terminalia tomentosa*. Measurements recorded by Mr. A. F. Broun at Bullawala near Dehra Dun in 1886 showed an average girth of 8 in. and an average height of 11 ft. 4 in. for coppice nine years old.

High forest. The annual rings are usually, but not always, quite distinct, and the rate of growth can thus as a rule be deduced from ring-countings. Measurements show the growth to be extremely variable. Gamble says Himalayan specimens show 5 rings per inch of radius, giving a mean annual girth increment of 1·26 in.; a specimen from the bed of the Mahanadi, Darjeeling *tarai*, showed 3·8 rings per inch of radius, giving a mean annual girth increment of about 1·7 in., which is fast.

Extremely slow growth is shown in an unthinned riverain sample plot of *khair* mixed with *Dalbergia Sissoo* in the Saharanpur Siwaliks in a somewhat dry locality with a soil of sand and boulders. The measurements, which applied to forty-five trees and extended over five years only (1910–11 to 1915–16), gave the following results:

Acacia Catechu: girth increment in unthinned sample plots, Siwaliks, United Provinces.

Age.	Mean girth.		Age.	Mean girth.	
years.	ft.	in.	years.	ft.	in.
10	0	0¼	70	1	5¾
20	0	2	80	1	10
30	0	4½	90	2	2¼
40	0	7	100	2	6½
50	0	9½	110	2	10
60	1	1½			

Although these results can hardly be regarded as very accurate owing to the short period over which the measurements extended and to the fact that dominated and suppressed trees were included, they emphasize the importance of carrying out regular thinnings to promote more rapid growth. A somewhat faster rate of growth is shown in an unthinned sample plot in the Sathiana block of the North Kheri forests. Measurements, which extended over eight years and related to seventy-five trees, gave the following results:

Acacia Catechu: girth increment in unthinned sample plot, Sathiana block, North Kheri, United Provinces.

Age.	Mean girth.		Age.	Mean girth.	
years.	ft.	in.	years.	ft.	in.
20	0	8	90	4	0
30	1	2½	100	4	5
40	1	8½	110	4	10
50	2	2	120	5	2½
60	2	7½	130	5	7
70	3	1	140	5	11
80	3	6½			

This plot was situated within the limits of the sal forests, not on recent alluvium.

Measurements of 100 trees by Mr. Beadon Bryant in the Kumaun sub-Himalayan tract gave the following results : [1]

Girth.	Average age. years.	Average volume. cub. ft. solid.
Over 4 ft. 6 in.	53	35·0
3 ft.–4 ft. 6 in.	36	16·5
1 ft. 6 in.–3 ft.	20	4·0
1 ft.–1 ft. 6 in.	15	1·3

Periodical measurements of 117 trees in three unthinned sample plots in the Palamau district of Bihar and Orissa gave the following results : [2]

Acacia Catechu : girth increment in unthinned sample plots, Palamau, Bihar and Orissa.

Age. years.	Mean girth. ft.	in.	Age. years.	Mean girth. ft.	in.
30	0	4¾	90	1	10½
40	0	7½	100	2	2¾
50	0	10¼	110	2	7½
60	1	0¾	120	3	0¾
70	1	3½	130	3	7
80	1	7			

Mr. W. R. Fisher [3] records very rapid growth in a plantation at Kuch Behar where the seed was sown in 1873 and 1874 : measurements made in 1881, the plantation being then seven to eight years old, showed an average and maximum girth of 1 ft. 6 in. and 2 ft. 1 in. respectively.

Measurements recorded by Mr. J. Nisbet [4] from the dry, intermediate, and moist zones in Upper Burma showed rapid growth, particularly in the moist zone. The following is a summary :

Acacia Catechu : girth measurements, Upper Burma.

District.	Character of forest.	Number of measurements.	Mean annual girth increment. in.
Yamethin and Meiktila	Dry zone : dry open forest and scrub jungle	8	2·2
Yamethin and Meiktila	Intermediate zone : mixed forest and scrub jungle	3	2·2
Yamethin (Pyinmana subdivision) and Minbu	Moist zone : mixed and savannah forest	10	3·54

Ring-countings which I carried out in 1902 in the Meiktila district of Upper Burma on twenty stumps in pure riverain cutch forest on sandy soil gave the following results :

Acacia Catechu : girth increment, riverain forest, Meiktila district, Upper Burma.

Age. years.	Girth including bark. ft.	in.	Mean annual girth increment. in.
5	0	6	1·2
10	1	8	2·0
15	3	0	2·4
17	3	6	2·47

[1] Working Plan for the Kumaun Forest Division, 1893.

[2] Ind. For. Records, vol. vi, pt. v.

[3] Ind. Forester, vii (1881), p. 41.

[4] *Ibid.*, xix (1893), p. 11.

This shows rapid growth, and as the rings were perfectly distinct the figures may be regarded as accurate. The diameter of heartwood averaged 0·67 of the whole diameter including bark.

Proportion of heartwood. The following measurements by Mr. A. Rodger of about 100 sections of cutch trees in the Thayetmyo and Prome districts of Burma show that the percentage of heartwood increases with size :

Acacia Catechu : measurements of heartwood in trees of different sizes.

Diameter including bark.	Corresponding girth.		Diameter of heartwood.	Percentage of total area of section occupied by heartwood.
in.	ft.	in.	in.	
6	1	7	3·6	35
7	1	10	4·7	45
8	2	1	5·6	49
9	2	4	7·0	61
10	2	7	8·0	64
11	2	11	9·0	67
12	3	2	9·0	56
13	3	5	10·3	65
14	3	8	10·7	59
15	3	11	12·5	64
16	4	2	12·5	61
17	4	5	13·6	63
18	4	9	15·2	68
19	5	0	16·0	70
20	5	3	17·0	73
21	5	7	18·2	75
22	5	9	18·7	72
24	6	3	21·2	80

4. **Acacia modesta**, Wall. Syn. *Mimosa dumosa*, Roxb. Vern. *Phulai*, Punjab.

A moderate-sized thorny tree with a bushy rounded crown and drooping branchlets. Bark rough, with numerous irregular cracks. Sapwood large, white : heartwood very hard, dark brown with black streaks, not durable, used for cane-crushers, Persian wheels, and agricultural implements, and largely for fuel. The tree is useful for afforestation purposes on poor stony soil in the dry lower hills and plains : it also makes a good hedge plant if trimmed.

This tree occurs more or less gregariously in the dry outer hills and valleys of the Suliman Range, ascending to 4,000 ft. in the Salt Range, the sub-Himalayan tract from the Jumna westwards, ascending to 4,000 ft., the northern part of the Punjab plains, and Baluchistan. In Hazara it is common on limestone in the scrub forests of Khanpur, and occurs in the Kagan valley on hot shaly hill-sides up to 5,500 ft. Within its natural habitat the rainfall varies from 15 to 50 in., the absolute maximum shade temperature may rise to over 120° F., and the absolute minimum may sink to well under freezing-point.

It is found on various geological formations, including limestone, sandstone, conglomerate, and shale, and is capable of growing in poor dry shallow soil where few other species can survive. It may occur pure or in mixture with other trees. Among its commoner associates are *Olea cuspidata*, *Acacia Catechu*, *Flacourtia Ramontchi*, *Tecoma undulata*, *Prosopis spicigera*, *Bauhinia variegata*, *Odina Wodier*, *Zizyphus Jujuba*, *Ehretia laevis*, and other miscel-

laneous species, often with an undergrowth of *Dodonaea viscosa*, *Carissa spinarum*, *Adhatoda Vasica*, *Woodfordia floribunda*, and other shrubs. It extends into the lower limits of *Pinus longifolia* in some parts of the outer Punjab hills. On poor dry localities at low elevations it is sometimes associated with *Salvadora oleoides* and *Capparis aphylla*. The new leaves appear in March: they are of a delicate green colour, but turn later to an ashy grey. The spikes of fragrant white flowers appear from March to May, when the trees are conspicuous with their masses of white tasselled blossoms. The pods ripen in the autumn and hang long on the tree; they are 2–3 in. long by 0·5 in. broad, flat, indehiscent, three- to five-seeded. The seeds, like those of *A. arabica*, are subject to the attacks of weevils. The tree seeds freely at frequent intervals, but occasional bad seed-years occur.

The tree is a drought-resistant species. It coppices well, and is usually worked as coppice-with-standards. The coppice-shoots as well as seedling plants require protection from browsing, as they suffer much damage from goats, sheep, and camels. Seedling reproduction is somewhat disappointing, and in many localities grazing is largely the cause of this. The tree has been raised artificially by direct sowings in afforestation operations in the outer hills.

An attempt was made by Mr. A. M. Reuther during the preparation of the Kalachitta working plan [1] to deduce the rate of growth by ring-countings on stumps of trees selected and felled for the purpose. As the rings are not always easy to distinguish he was unable to place absolute reliance on the results, which must be taken as approximate only. From the recorded measurements the following statement showing the approximate rate of growth has been prepared:

Acacia modesta: rate of growth in Kalachitta forest.

Age. years.	Mean height. ft.	Mean girth. ft.	in.
10	6·0	0	5·7
20	12·0	0	11·4
30	15·0	1	5·0
40	17·5	1	10·8
50	19·7	2	4·6

Parker says the growth is very slow, plantations made in the sub-Himalayan tract having reached a height of 18–20 ft. in as many years, though the girth was only about 1 ft. at the base.

5. **Acacia Senegal,** Willd. Syn. *A. rupestris*, Stocks. Vern. *Khor*, Sind; *Kumta*, Rajputana.

A small thorny deciduous tree, usually gnarled, ordinarily reaching a height of 10–15 ft. and a girth of 1–2 ft. Bark smooth, pale greenish grey, peeling off in flakes and exposing the yellowish new bark underneath; branches smooth, grey, shining, flexuose. The wood, which is hard with a nearly black heartwood, is used for weavers' shuttles and for fuel, and the true gum-arabic of commerce is obtained from wounds in the bark. In habit and appearance the tree resembles *A. modesta*, but is readily distinguished by its smooth pale bark, its infra-stipular spines in threes, and its larger pods.

This is a tree of the arid regions of India, occurring on the dry rocky hills of Sind, the south-east Punjab, the Aravalli, and the other hills of Raj-

[1] Working Plan for the Kalachitta Forest, Rawalpindi Forest Division, 1897.

putana, where it is abundant, and Ajmer ; it is also found in Arabia and Africa. In its Indian region the absolute maximum shade temperature may rise to over 120° F., and the absolute minimum may sink to well under freezing-point, while the normal rainfall varies from about 10 to 25 in. The tree occurs on the poorest soil on rocky hills and sandy tracts. In Ajmer it is associated with *Anogeissus pendula*, *Acacia Catechu*, and *Boswellia serrata* : here it produces abundant seed every year, and is said to regenerate freely under conditions adverse enough to prevent the regeneration of *A. Catechu*. Parker says it regenerates much more freely than *A. modesta*, and that it has been employed successfully for afforesting bare rocky hills and shifting sand in the Jaipur state, Rajputana. Mr. E. McArthur Moir,[1] writing of sowings of this and other species in the dry regions of Ajmer-Merwara, notes that the seedlings died back for two or three years before finally establishing themselves and becoming capable of resisting drought and frost, developing in the meantime taproots of great length and thickness. The tree is readily browsed by camels and goats. It is a hardy species, surviving under most adverse conditions.

The fragrant white flowers, in lax spikes 2–4 in. long, appear from August to December ; the pods, which ripen the following spring, are 3 in. long by 0·7 in. broad, thin, flexible, brown when ripe, five- or six-seeded, tardily dehiscent.

6. **Acacia planifrons,** W. and A. Umbrella thorn. Vern. *Kodaivelam*, *odai* (which is also a name given to *A. Latronum*), Tam. ; *Godugu thumma*, Tel.

A small to moderate-sized tree with a flat spreading dense umbrella-like crown, common and often gregarious in the southern parts of the Indian Peninsula, in the south Deccan, Salem, Madura, Tinnevelly, and Travancore, in dry forests, often occurring along with *A. Latronum*, and sometimes also with *A. arabica*, *Albizzia amara*, *Dichrostachys cinerea*, *Chloroxylon Swietenia*, and a few others. Mixed with *A. Latronum* it forms at times a dense and impenetrable growth, but often it occurs in stunted form in open crops. In shape it exhibits the umbrella form characteristic of tropical open xerophilous woodland. The tree reproduces from root-suckers when felled ; in the Tinnevelly district it is worked for the production of fuel as simple coppice on a rotation of fifteen years, reproduction being largely from root-suckers. Seedling reproduction is also said to be good in open places.

7. **Acacia Latronum,** Willd. Vern. *Odai* (also a name given to *A. planifrons*), *odai usal*, Tam. ; *Jala*, Tel.

A gregarious very thorny shrub or small tree resembling *A. planifrons* in its spreading umbrella-like crown, but smaller than that species. It is common in the dry parts of the Deccan and southern India, covering considerable stretches of country with a dense impenetrable thorny scrub, and often growing on bare hard gravelly soil, both on flat ground and on the lower hill slopes, where it may perform a useful function in preventing erosion and in protecting young plants of other species from injury by browsing. It is readily browsed by goats itself, though its thorns afford a formidable protection. The thorns are of two kinds, one large, white, conical and hollow, often tenanted by large black ants, and the other shorter and slender. Among its more common associates are *Acacia planifrons*, *A. leucophloea*, *A. arabica*,

[1] Ind. Forester, iv (1879), p. 387.

Albizzia amara, *Randia dumetorum*, *Azadirachta indica*, *Dichrostachys cinerea*, and *Chloroxylon Swietenia*. On poor soils it is sometimes associated with *Acacia eburnea*, *Balanites Roxburghii*, and *Capparis aphylla*.

8. **Acacia Farnesiana,** Willd. Syn. *Vachellia Farnesiana*, W. and A. Cassie flower. Vern. *Wilayati babul, wilayati kikar, gukikar*, Hind.; *Jalli*, Kan.; *Kankri*, Mar.; *Nanlongyaing*, Burm.

A thorny shrub or small tree reaching a height of 15 ft. or sometimes more, with fragrant flowers from which a perfume is extracted; it yields a gum. Indigenous in tropical America; cultivated and self-sown throughout the greater part of India and Burma. In northern India it is sometimes found gregariously in river-beds on loose sandy soil, a condition which appears to favour its establishment. On the plains of the Punjab it grows well on pure sand in fairly dry places, and would probably do well for sowing up shifting sands.

The flowering season is somewhat irregular, but lasts chiefly from November to March; the bright yellow globose flower-heads are powerfully scented. The pods form rapidly, and are usually full-sized but still green by May. They commence ripening about July (Dehra Dun), but hang long on the tree, and may be collected almost any time. The pods are 2–3·5 in. long by 0·5 in. thick, nearly cylindrical, pointed at both ends, turgid, dark brown when ripe, with a double row of numerous seeds embedded in dry spongy tissue; they are hardly dehiscent. About 300–340 seeds weigh 1 oz. The pods usually fall without dehiscing, and the valves become eaten by insects or decay or are beaten open by heavy rain, the seeds being washed out. The seeds often germinate within the pod, a dense clump of seedlings resulting. Germination takes place during the rains, but many seeds remain on or in the ground for a whole year, germinating in the second rains. At Dehra Dun the season's growth ends about December; the leaves commence falling in November–December and the plants are leafless or nearly so in January–February, the new leaves appearing in February–March.

Under favourable conditions the growth of the seedling is rapid. Seed sown at Dehra Dun in May in a nursery-bed regularly watered and weeded produced plants up to 7 ft. high by the end of the first season, and these flowered early the next year. In another plot seedlings regularly weeded but not watered reached maximum heights of 2 ft. 1 in. and 7 ft. 10 in. by the end of the first and second seasons respectively, and by the end of the third season the dominant plants varied from 7 ft. to 14 ft. 4 in. in height; they commenced flowering in the end of the second season and the pods ripened successfully in the third season, the plants being then about two years old. The plants require free growing space, and the smaller ones are quickly suppressed and outgrown by the more vigorous ones. They stand frost fairly well.

9. **Acacia eburnea,** Willd. Syn. *Mimosa eburnea*, Roxb. Vern. *Pahari kikar*, Hind.; *Marmati*, Mar.; *Odai vél, kal odai*, Tam.

A large shrub or small tree with rough dark grey bark, sparse greyish foliage and straight spines, the larger ones white and up to 2 in. long. Though nowhere abundant, it is widely distributed in the drier parts of India, extending westward into Arabia. In the sub-Himalayan tract it occurs in dry river-beds along with *A. Catechu*. In the Indian Peninsula it is found in open thorn

forests on dry stony soil, associated with *A. Catechu*, *A. Latronum*, *A. leucophloea*, *Prosopis spicigera*, and other species, and on the poorest ground with *Balanites Roxburghii* and *Capparis aphylla*. It is associated with *Acacia arabica* on black cotton soil, but where this gives place to shallow *murram* or calcareous soil with rock or a clay stratum near the surface it replaces that species.

The yellow flower-heads, which have a somewhat unpleasant odour, appear from November to March, and the pods ripen from April to June.

10. **Australian acacias.** Three important Australian acacias, *A. decurrens*, Willd., *A. dealbata*, Link, and *A. Melanoxylon*, R.Br., have been introduced into India, chiefly in the Nilgiris, but to some extent also in the Himalaya and other hill tracts. In the Nilgiris they have become such a feature in the landscape that a brief account of their introduction and propagation in these hills will not be out of place.

A general description of the topography and climate of the Nilgiris will be found under *Eucalyptus Globulus*, the exotic tree *par excellence* in that region. Australian acacias appear to have been introduced first in the early forties of last century, mainly with the object of providing fuel, of which there was a great shortage at that time. Although as plantation trees they have been outclassed by *Eucalyptus Globulus*, still the acacias—chiefly *A. dealbata* and *A. Melanoxylon*, and to a smaller extent *A. decurrens*—were extensively planted, partly in mixture with eucalyptus and partly alone. The actual area of pure acacia plantations owned by Government in 1912 amounted to 322 acres ; in addition there are considerable areas of eucalyptus and acacias mixed, at elevations varying from 5,000 to 8,300 ft. These acacias are also to be found along roadsides, on waste land, in private plantations, and in gardens. *A. dealbata* has spread by root-suckers to such an extent as to become in many cases a nuisance.

The acacias appear to have been propagated from transplants and not by direct sowings, and this system has answered well. Spacings of 6 ft. by 6 ft. to 9 ft. by 9 ft. have been the general rule in plantations. The Government plantations, whether pure or mixed with eucalyptus, are worked for the production of fuel under the system of simple coppice. The rotation adopted until recently was one of ten years, but in 1913 it was raised to fifteen years. Under the coppice system, *A. Melanoxylon* is gradually dying out, and in a few unimportant cases it is being maintained, where pure, as high forest. Where acacia is mixed with eucalyptus the resulting crop becomes a two-storied coppice, owing to the more rapid growth of the eucalyptus.

The following particulars regarding the three acacias in question may be of interest :

(1) **Acacia decurrens,** Willd. Green wattle. An evergreen tree ; bark olive green when young, dark grey on older trees. Branchlets and foliage nearly glabrous and not hoary ; decurrence of leaf-stalks very marked. Flowers paler yellow and less plentiful and less strongly scented than in *A. dealbata* ; pods narrow and constricted between the seeds. Maiden describes six varieties, but admits that the gradations from one to another are slight. Var. *mollis*, Lindl., has tomentose foliage, but the pubescence on the branchlets is golden yellow ; this variety is regarded in Australia as the best tannin producer

among the acacias, and Maiden quotes yields of 32 to 36 per cent. of tannic acid in bark samples. Analyses of Nilgiri bark samples of the typical variety made at the Indian Institute of Science in 1912 gave 24·42 per cent. of tannin. In India it is nowhere plentiful enough to yield regular supplies of bark in quantity.

This species (or variety) is a native of Queensland, New South Wales, Victoria, and Tasmania. It is far less plentiful in the Nilgiris than *A. dealbata*; it has been planted in fair abundance along roads in Coonoor, but is not so common at Ootacamund, and is comparatively rare in the plantations. Its general habits in the Nilgiris are somewhat similar to those of *A. dealbata* described below; it reproduces well by coppice-shoots and root-suckers, but not so freely as that species. Its growth is more erect than that of *A. dealbata.*

(2) **Acacia dealbata,** Link. (*A. decurrens,* Willd., var. *dealbata,* Von Mueller *ex* Maiden.) Silver wattle. An evergreen tree with grey, sometimes silvery bark. Young branchlets angled, hoary, covered with minute pubescence; foliage also hoary. Flower-heads in profuse axillary and terminal panicled racemes, globose, about 0·15–0·2 in. in diameter, deep saffron yellow, strongly scented. Pods straight or curved, flattened, 2–3 in. long by 0·25–0·5 in. broad, broader and less constricted between the seeds than in *A. decurrens*; decurrence of leaf-stalks less marked than in the latter. Maiden regards *A. dealbata* as merely a variety of *A. decurrens.*

In Australia it ordinarily attains a height of 50 ft. and a girth of 3–6 ft.; in Tasmania a tree has been recorded about 100 ft. in height and 11 ft. 2 in. in girth. In the Nilgiris it seldom attains a height of over 40 ft. or a girth of over 4 ft. In Australia the timber is considered of little value, and is used chiefly for making cheap cask-staves. In the Nilgiris it is used as fuel, for which purpose it is considered good. The bark is not so rich in tannin as that of *A. decurrens.* Maiden says that in Australia the best samples of bark contain about 25 per cent. of tannic acid. Analyses of Nilgiri bark made at the Indian Institute of Science in 1912 showed 9·56 per cent. of tannin.

The tree is a native of New South Wales, Victoria, Queensland, and Tasmania. It has been extensively planted in the Mediterranean Riviera and elsewhere. In India it has become thoroughly naturalized in the Nilgiri and Palni hills, and has been planted in the Himalaya.

In the Nilgiris this tree, together with the blue gum, is one of the most characteristic features of the vegetation from 5,000 ft. upwards. One of its most striking peculiarities is its extraordinary power of reproduction by root-suckers, which come up in dense masses of thin whippy shoots, and spread with great facility. For this reason it is almost unrivalled as a means of clothing unstable hill slopes; in the neighbourhood of gardens, however, it is an intolerable nuisance owing to its powers of spreading and the difficulty of eradicating it, which is possible only by deep hoeing and extraction of all the roots. Another peculiarity of this tree in the Nilgiris is its straggling and sometimes almost recumbent habit of growth, erect trees being quite exceptional. It is very liable to breakage from wind. In the Nilgiris it has proved an excellent under-story to the eucalyptus in the grass-land type of plantations, where a soil-protective undergrowth is desirable: it appears to stand the light shade of the eucalyptus well, and reproduces freely by coppice. Fig. 174

FIG. 174. Coppice of *Eucalyptus Globulus* and *Acacia dealbata*, 6 years old, the latter forming an underwood to the former, Coonoor Peak plantation, Nilgiris.

FIG. 175. Coppice of *Acacia dealbata*, with younger coppice intermingled with numerous root-suckers in foreground, Nilgiris.

shows a crop of *Eucalyptus Globulus* coppice with *Acacia dealbata* coppice as an under-story, and Fig. 175 shows pure coppice of acacia, in which numerous root-suckers are intermingled. The tree has been found to have a powerful nitrogenizing action on the soil, and is thus a good natural fertilizer. In France it is said not to thrive on soil containing lime ; the soil of the Nilgiris is particularly free from lime, and this may possibly favour its extraordinary vegetative activity on those hills.

As regards the yield of plantations, Mr. S. Cox [1] points out that it is hardly possible to give accurate figures for *A. dealbata* by itself, as it has been universally planted with *A. Melanoxylon*, and although in the plantations regularly coppiced for fuel the latter has largely died out there is always a small proportion left. Allowing for error caused by the mixture of the two species, the general average yield of coppice from ten to fifteen years old in the second rotation may be said to be from 2,000 to 3,000 cub. ft. stacked per acre.

The tree has been commonly planted in the Himalaya, for example at Simla and in the Naini Tal and Almora hills, chiefly between 6,000 and 8,000 ft. elevation. It suffers considerably from snow-break, but where its value lies in its adaptability for afforestation purposes this is not a serious drawback. In the abnormal frost of 1905 it suffered to a considerable extent, particularly at the higher elevations, but the check to the growth resulted in the production of numerous root-suckers. In the Naini Tal hills it stood the abnormal drought of 1907 and 1908 well where most other exotic species were badly damaged. In the Himalaya the tree flowers from January to March, and the seed ripens in June : in cold situations the fruit fails to ripen. When in flower the trees, laden with yellow blossom, are a striking sight.

(3) **Acacia Melanoxylon**, R.Br. Australian blackwood.

An evergreen tree, in its natural home ordinarily reaching a height of 60 to 80 ft. and a girth of 6 ft. Exceptionally it is said to reach a height of 120 ft. and a girth of 10 ft. In the Nilgiris it often reaches a height of 80 ft., but seldom attains a girth of over 5 ft. On rich soil it grows luxuriantly : thus in the Rallia plantation near Coonoor, where it is mixed with *Eucalyptus Globulus*, occasional trees reach a height of 110 ft. at an age of forty years, though the girth averages less than 3 ft., the trees having been drawn up to height by close planting (see Fig. 176). The largest recorded measurements in the Nilgiris are those made by Mr. Cowley-Brown in the case of a tree forty-nine years old in Bleak House plantation ; these are : (1) height 127 ft., (2) girth at breast height 6 ft. 4 in., (3) estimated volume 212·5 cub. ft. (timber only). This tree has since been killed by *Loranthus*. Trees fifty-two years old in the Marlimund block on deep moist soil measured up to 100 ft. in height and 5 ft. in girth.

Acacia Melanoxylon is a larger tree, with more erect habit, straighter bole, and denser crown, than *A. decurrens* or *A. dealbata*. The dense olive-green foliage, consisting mainly of phyllodes and not of true leaves, forming a symmetrical tapering crown reaching low down, makes it one of the handsomest of the exotic trees in the Nilgiris ; its general appearance is unlike that of a typical acacia. The young branchlets are angled, minutely grey tomentose, rarely glabrous. Phyllodes coriaceous, glabrous, lanceolate or oblong, usually

[1] Working Plan for the Nilgiri Plantations, 1913.

falcate, variable in size, usually 2·5–4 in. long by 0·3–0·8 in. broad. True bipinnate leaves often present, especially on young trees. Flower-heads 3 to 4 in axillary racemes, globose, yellow, about 0·2 in. in diameter. Pods linear, flat, often curved in a circle, 2–4 in. long by 0·3–0·4 in. broad. Seed small, with a long pale red funicle which encircles it.

The timber is of very good quality, dark brown, beautifully mottled, and is used in Australia for furniture, gunstocks, railway carriages, and other purposes. In the Nilgiris there is little demand for it for such uses. Analyses of Nilgiri bark at the Indian Institute of Science in 1912 gave 7·04 per cent. of tannin.

The tree is a native of Tasmania, Victoria, and New South Wales, and extends into South Australia and Queensland: it grows typically on rich soil. It has been fairly extensively planted in the Nilgiris, where it does well on fertile soil, but it is slowly dying out, partly owing to its susceptibility to the attacks of a *Loranthus*, which kills off numbers of trees, and partly to the fact that its coppicing powers are feeble. It reproduces by root-suckers, but not to the same prolific extent as *A. dealbata*. On deep moist fertile soil its growth is fairly rapid, as the figures quoted above show. Mr. D. E. Hutchins found in 1883 that trees in the Nilgiris gave about four rings per inch of radius and an annual increment of about 5 to 6 tons of wood per acre.

4. ALBIZZIA, Durazzini.

This genus contains fourteen Indian species, all trees, some of which are of importance in Indian silviculture. Perhaps the most characteristic feature of the genus, as affecting the distribution of the seed, is the pod, which is thin, flat, and dry, developing rapidly after the flowering, but taking some time to ripen fully; in most cases dehiscence does not take place fully until after the pods fall, and as they fall chiefly in the hot season when dry winds are prevalent, they may be blown to some distance from the tree. In some cases, especially in *A. Lebbek*, the seeds are very liable to destruction by insects, and this probably explains to a considerable extent the absence of reproduction where such damage is prevalent. Germination is epigeous. Some species produce root-suckers freely, e. g. *A. lucida*, *A. mollis*, and *A. odoratissima*. The growth of some is extremely rapid, e. g. *A. moluccana* (not indigenous) and *A. stipulata*. The species vary in soil moisture requirements from *A. procera*, which thrives on moist and even swampy ground, to *A. amara*, which grows on poor dry soils in the Indian Peninsula.

Species 1. *A. Lebbek*, Benth.; 2. *A. stipulata*, Boivin; 3. *A. procera*, Benth.; 4. *A. odoratissima*, Benth.; 5. *A. lucida*, Benth.; 6. *A. amara*, Boivin; 7. *A. mollis*, Boivin; 8. *A. moluccana*, Miq.

1. **Albizzia Lebbek**, Benth. Siris, East Indian walnut. Vern. *Siris*, Hind.; *Chichola*, Mar.; *Sirsul*, Kan.; *Dirasanam*, Tel.; *Vagai*, Tam.; *Kôkko*, Burm.

A moderate-sized or large deciduous tree; bark dark grey, rather rough with irregular cracks, red or crimson inside. In the open the tree forms a short bole, branching low down, with a broad crown, but in the forest

FIG. 176. Mixed plantation of *Eucalyptus Globulus* and *Acacia Melanoxylon*, 40 years old, Rallia plantation, Nilgiris.

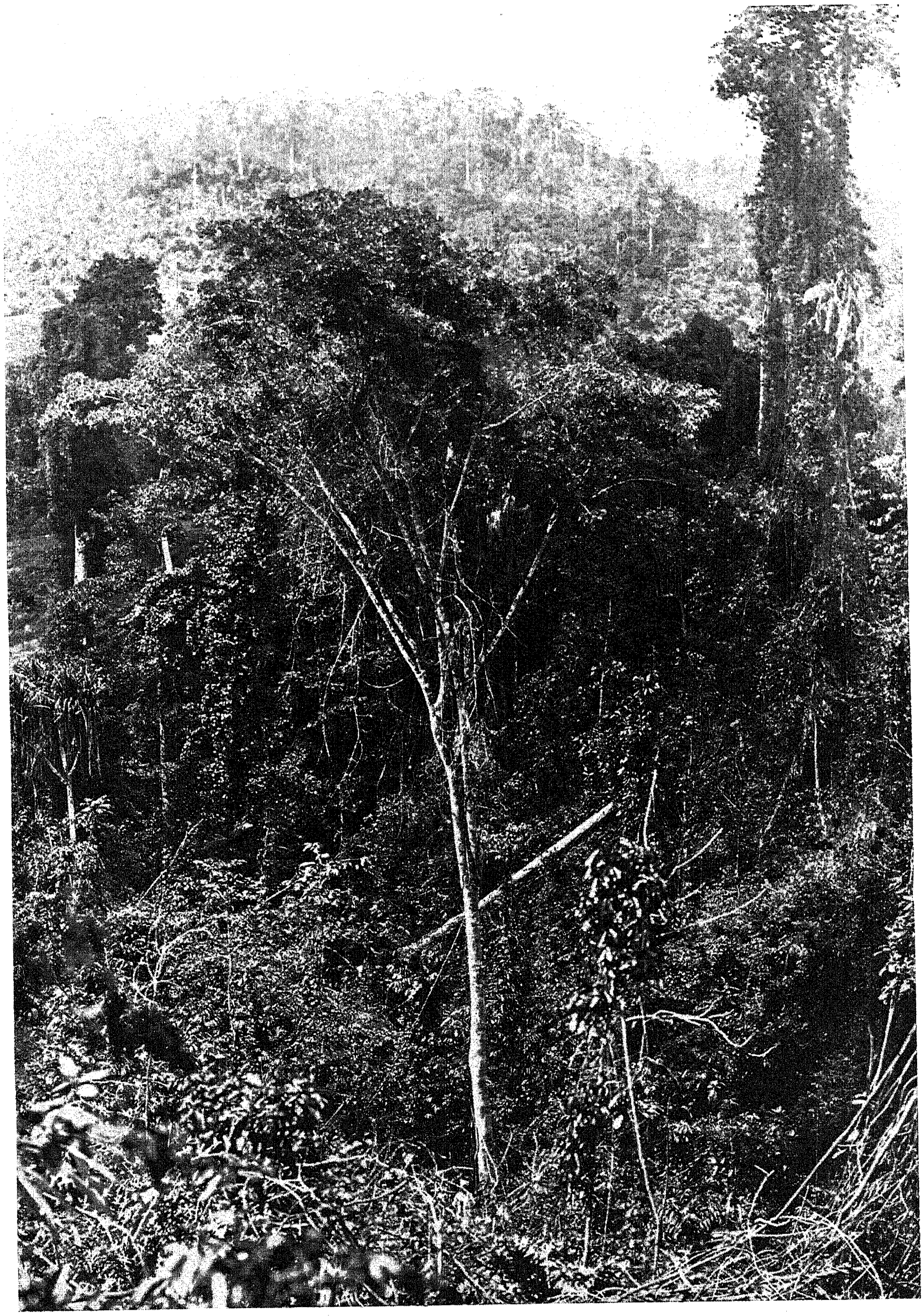

FIG. 177. *Albizzia Lebbek* in evergreen forest, Andamans.

when drawn up by other trees it produces a long straight bole. In the Andamans it is said to yield squares up to 50 ft. long with 3 ft. siding.

The sapwood is whitish and large, the heartwood dark brown with lighter or darker streaks, ornamental, used for building, furniture, agricultural and other implements, carving, turning, &c. The burrs are particularly valuable.

DISTRIBUTION AND HABITAT. The tree has been so extensively planted in gardens, along roadsides and in other places, from which it has probably run wild, that its natural habitat is difficult to determine. It is believed to be wild in the sub-Himalayan tract, Bengal, Chota Nagpur, the Indian Peninsula, Burma, and the Andaman and Cocos islands. In the Himalayan valleys it occurs up to 4,000 ft. or sometimes more, usually along the banks of streams. Haines has come to the conclusion that it is nowhere wild in the southern forest circle of the Central Provinces, though very commonly planted, but the tree often called *A. Lebbek* is *A. odoratissima*, Benth., var. *lebbekifolia* Haines. Talbot says it is scattered throughout the Bombay Presidency in dry and moist monsoon forests. It is undoubtedly wild in some of the Madras forests, and Bourdillon says it is wild in the deciduous forests of Travancore at low elevations. It is a tree of the mixed deciduous forests, in both dry and moist types, or of moist semi-evergreen or even evergreen forest, usually occurring scattered and not gregariously. In the Andamans it is a regular forest tree, and occurs not only in the semi-deciduous or padauk-bearing forest but also in the evergreen forest: in the former it is associated with *Pterocarpus dalbergioides*, *Lagerstroemia hypoleuca*, *Terminalia bialata*, *Bombax insigne*, *Sterculia alata*, *S. villosa*, *Myristica Irya*, *Artocarpus Chaplasha*, and other species, while in the evergreen forest its chief companions are *Dipterocarpus turbinatus* and other species of *Dipterocarpus*, *Planchonia andamanica*, *Artocarpus Chaplasha*, *A. Lakoocha*, *Myristica Irya*, *Calophyllum spectabile*, *Mesua ferrea*, *Hopea odorata*, *Mimusops Elengi*, *Baccaurea sapida*, and *Podocarpus neriifolia*. Fig. 177 shows a tree in evergreen forest.

Mr. F. H. Todd[1] notes that in the North Andaman its northern limit, except for occasional specimens, is the Balmi creek, and that it is particularly abundant in Interview and Bennett Islands, in which from valuation surveys he estimated the stock to be: (1) trees 6 ft. in girth and over, 7,820; (2) trees $4\frac{1}{2}$–6 ft. in girth, 3,275; (3) trees 3–$4\frac{1}{2}$ ft. in girth, 3,275. He also mentions that in the North Andaman the tree grows best in the moist semi-evergreen forests, and though fairly numerous in the deciduous forests, it is usually somewhat stunted.

More recent estimates from enumerations by Mr. Bonig, in which Mr. Todd's figures are incorporated, give the following figures: [2]

	Trees over 6 ft. in girth.	Trees under 6 ft. in girth.
North Andaman felling series	10,725	—
Middle Andaman felling series	18,133	21,624
Southern Andaman felling series	1,220	4,990

In Burma it grows in tropical forests as well as in mixed deciduous forests.

[1] Draft Working Plan for the Forests of the North Andaman, 1906.

[2] Working Plan Report of the Andamans Forest Division, 1916.

In the former Brandis[1] mentions it as one of the lofty deciduous trees towering above the evergreen trees, other large deciduous trees growing with it being *Xylia dolabriformis*, *Albizzia stipulata*, *Tetrameles nudiflora*, *Pentace burmanica*, *Sterculia* spp., &c. It is found both in the moist upper mixed forests and in the dry mixed forests. In the former it is associated with teak, *Xylia*, *Lagerstroemia Flos-Reginae*, *Dipterocarpus alatus*, and many other trees, the chief bamboos being *Bambusa polymorpha* and *Cephalostachyum pergracile*. In the dry mixed forests its chief companions are *Pentacme suavis*, *Shorea obtusa*, *Buchanania latifolia*, *Dalbergia cultrata*, *Terminalia tomentosa*, *Phyllanthus Emblica*, *Dillenia pulcherrima*, *Cassia Fistula*, and others, sometimes with teak of comparatively small size; the chief bamboo is *Dendrocalamus strictus*.

In the dry forests of the Madras Presidency it is found chiefly along streams and in moist places. It is frequently planted in dry regions, and on a variety of soils; it grows successfully when planted on black cotton soil.

Leaf-shedding, flowering, and fruiting. In northern India the leaves commence falling in October and November, and some trees are almost leafless by the end of November. Some are still in full leaf during December. In some cases the leaves continue falling from December to the end of February or even into March. The new leaves appear in April or sometimes as early as March. Trees or branches which yield fruits in plenty become leafless earlier and remain leafless longer than those which do not.

The flowers, of a somewhat heavy fragrance, appear chiefly in April and May, sometimes earlier or later, and the masses of yellowish white blossom are conspicuous against the new foliage.

The fruits develop rapidly, and by August some are nearly full-sized. In northern India they approach maturity by October, though still green, and begin to turn yellow in November, ripening soonest on trees which have lost their leaves; by December or January the pods are all ripe. Farther south they ripen sooner. They hang on the tree as a rule until March, when they commence to be blown down, but many continue hanging through April and May, some exceptionally remaining on the trees as late as October, so that from July onwards old yellow pods may be seen hanging along with young green ones. Heavy rain from March onwards brings down the pods in quantity.

The ripe pods are straw coloured, 8–12 in. long by 1·2–2 in. broad, flat, thin, firm, linear-oblong, 6- to 12-seeded, the outlines of the seeds prominent on the outside. They rustle in the breeze with a characteristic sound which has been described as that of the frying of meat. On leafless trees they are often produced in great abundance, the trees having the appearance of being covered with dry light yellow foliage. The pods are dehiscent, but dehiscence does not as a rule take place until the pods have reached the ground, and may be tardy or only partial, the seeds remaining within the pod for a considerable time.

The seeds (Fig. 178, *a*) are 0·3–0·45 in. by 0·25–0·35 in., obovate or oblong, compressed, light brown, smooth, with a hard testa. Their weight varies considerably, from 140 to 350 (average 230) weighing 1 oz. Tests carried out

[1] Report on the Attaran Forests.

FIG. 178. *Albizzia Lebbek*—SEEDLING × $\frac{3}{4}$

a—Seed b-d—Germination stages e-g—Development of seedling during first season

at Dehra Dun showed that the seed retains its vitality well for at least one year, though fresh seed has a higher percentage of fertility than seed which has been kept for a time ; seed kept for a year germinated more rapidly than fresh seed. The seeds are very subject to the attacks of insects, particularly of a small whitish caterpillar, and many are destroyed both on the tree and on the ground. Rain sometimes causes much of the seed to rot in the pods, particularly after they have fallen, and it is therefore advisable to collect the seed as soon after it ripens as possible. This can best be done by men ascending the trees and picking the pods off, or by knocking them off with the aid of a long stick ; in the latter case it is advisable to spread sheets under the trees, as much of the seed may fall out during the process. The seeds are extracted from the pods either by opening the latter or by crushing them in the hands and separating the seeds by winnowing.

GERMINATION (Fig. 178, *b–d*). Epigeous. The radicle emerges first, and the hypocotyl elongates by arching, soon straightening and carrying the cotyledons above ground ; as a rule the testa is carried up over the cotyledons, falling with their expansion, but sometimes it remains underground.

THE SEEDLING (Fig. 178).

Roots : primary root long, terete, tapering, wiry, brown : lateral roots moderate in number, short, fibrous, distributed down main root : nodules present. *Hypocotyl* distinct from root, 1·5–2 in. long, terete, tapering upwards, minutely pubescent. *Cotyledons* sessile, 0·6 by 0·4 in., elliptical ovate, apex rounded, base sagittate, flat or slightly plano-convex, fleshy, entire, green, glabrous. *Stem* erect, terete, wiry, green, pubescent ; internodes 0·1–0·5 in. long. *Leaves* alternate. Stipules minute, lanceolate. First leaf once paripinnate, rachis 0·6–1·3 in. long, leaflets opposite, five or six pairs, 0·4–0·7 in. by 0·15–0·17 in., obliquely oblong, subsequent leaves bipinnate, at first with one pair of pinnae 0·7–1·5 in. long, common rachis 0·5–1 in. long, the number of pairs of pinnae increasing subsequently.

The development of the seedling varies greatly among individual plants even under identical conditions, but there are certain factors which stimulate development, and which induce remarkably rapid growth from the commencement ; the most important factors are absence of weeds, loose soil, sufficient soil moisture, and full sunlight. Numerous experimental plots at Dehra Dun have demonstrated the marked effect of regular weeding and loosening of the soil on the growth of the seedling, and although watering has a beneficial effect it is of comparatively little avail unless weeding is carried out.

As regards light requirements, experimental plots of seedlings grown under shade of varying intensity have shown that dense shade greatly retards germination, some seed failing to germinate until the second year ; seedlings which do appear are capable of standing heavy shade for one season but not longer, and development is very slow, a maximum height of only 4 in. having been recorded at the end of the season. The seedlings develop satisfactorily with moderate side shade, but at Dehra Dun their growth was found to be inferior to that of plants grown in full sunlight. The following measurements recorded in various experimental plots at Dehra Dun exhibit the marked effects of regular weeding, whether accompanied by irrigation or not :

Albizzia Lebbek: rate of growth of seedlings in experimental plots.

Irrigated plots. Weeded.	Irrigated plots. Unweeded.	Unirrigated plots. Weeded.	Unirrigated plots. Unweeded.
Height at end of first season.			
(1) 1 ft. 2 in.–8 ft. 4 in. (nursery plants; seed sown Feb. and early start obtained) (2) Maximum 2 ft. 0 in.[1]	Maximum 1 ft. 5 in.[1]	Maximum 2 ft. 9 in.[1]	(1) Maximum 1 ft. 1 in. (2) ,, 0 ft. 7 in. (3) ,, 0 ft. 8 in. (4) ,, 0 ft. 10 in.
Height at end of 2nd season.			
(1) Maximum 14 ft. 4 in. (2) ,, 6 ft. 8 in.[1]	Maximum 4 ft. 5 in.[1]	Maximum 6 ft. 11 in.[1]	(1) Maximum 2 ft. 9 in.[1] (2) ,, 1 ft. 9 in. (3) ,, 2 ft. 9 in. (4) ,, 2 ft. 10 in.
Height at end of 3rd season.			
(1) Abandoned (2) Maximum 13 ft. 0 in. (dominant plants vigorous)	Maximum 11 ft. 0 in.	Maximum 14 ft. 9 in. (dominant plants vigorous)	(1) Maximum 4 ft. 10 in. (2) ,, 4 ft. 8 in.

[1] Growth of seedlings retarded by attacks of *Oxyrhachis tarandus*, Fabr., a hemipterous insect of the family Membracidae which infests seedlings and saplings of this and other species of *Albizzia* as well as certain other leguminous species (to some extent *Acacia Catechu*), doing much damage by sucking the young shoots and causing them to wither; the leading shoots are often destroyed in this way and the growth of the plants is seriously interfered with.

All the plots noted in the above statement were in full sunlight: the unirrigated unweeded plots may be taken to represent the development under natural conditions. Nursery-raised plants, regularly weeded and watered, show rapid growth from the commencement, and may attain a height of nearly 4 ft. in four months from germination. A long stout taproot is produced at an early stage; this may reach a length of 2 ft. in three to four months. The lateral rootlets are often covered with rather large nodules. In northern India the leaves of seedlings fall from about December to March, and growth ceases during the cold season; new growth commences about February.

The seedlings are not very frost-tender, though the leaves are apt to shrivel up in frosty localities before falling, and the leading shoots are sometimes killed back where frost is severe. Young plants are somewhat sensitive to drought, especially in the first season. If early rain stimulates germination and prolonged dry weather ensues, the young seedlings are killed off in quantity. Under natural conditions light weed-growth and grass, though it impedes development, acts as a protective against drought. The sudden removal of weeds from over young seedlings is fatal; weeding requires to be carried out from the commencement. Seedlings do not stand suppression well, and where they are at all crowded the more vigorous individuals quickly suppress the more weakly ones.

Silvicultural characters. Young plants are capable of standing a moderate amount of shade, though their growth is interfered with if the shade is at all heavy. For its best development the tree requires full overhead light. It is not exacting as to soil, and will grow fairly well even on laterite or black cotton soil. The root-system is largely superficial, and though as a rule the tree does not produce root-suckers regularly, it may do so if the roots are exposed. Mr. G. M. Ryan writes:[1] '*Albizzia Lebbek* is not a tree

[1] Ind. Forester, xxx (1904), p. 454.

which has been noticed to throw up root-suckers habitually, but a very interesting instance of such reproduction occurring on the exposure of the root-system came to my knowledge recently in the Wada Range (Thana district, Bombay), where 21 *Albizzia Lebbek* suckers were observed in some excavated pits arising from roots which were embedded to the depth of $1\frac{1}{2}$ ft. in the soil. A close examination proved that these suckers arose from a network of subterranean roots which spread out from an *Albizzia Lebbek* 100 ft. away.' Its shallow root-system renders it liable to be thrown by wind. The tree is browsed by camels and lopped for camel fodder. It is sometimes badly attacked by *Loranthus*.

Natural reproduction. Under natural conditions germination ordinarily commences early in the rainy season and may continue until late in the rains. If the seeds are exposed to full sunlight germination is usually prompt and complete, but under shade it is delayed, and seed may lie ungerminated until the following year. In full sunlight, however, there may be high mortality if dry weather occurs after rain during or shortly after germination, and the survival of the seedlings is surer in a moderate growth of grass and weeds than if they are fully exposed to the sun, though their development is impeded. The ideal conditions for natural reproduction appear to be loose fairly moist soil, free from weeds, under light shade preferably from the side, the shade being removed when the seedlings have established themselves.

The sporadic nature and uncertainty of natural reproduction in most localities is noticeable. Seedlings in various stages are occasionally met with, but considering the large quantities of pods produced natural reproduction is decidedly scanty. It is probable that insect attacks account for this to a large extent, and an experiment carried out at Dehra Dun appears to support this view. Pods which were knocked off the trees by heavy rain in March were placed on a plot of ground which had been previously dug up, germination being thus favoured. The pods, which were left uncovered as under natural conditions, gradually dehisced and the seed began to fall out in May, but by July every seed had become badly attacked by insects, and not a single one germinated, although the plot was kept under observation until the end of the year. Drought is no doubt also a fruitful cause of failure, in dry localities and on stiff or shallow soils, particularly during germination and in the early seedling stages. Heavy shade, in retarding germination and thus prolonging the period during which the seed is exposed to insect attacks, is another adverse factor.

Artificial reproduction. *Albizzia Lebbek* can be grown by direct sowings and by transplanting from the nursery, but experiments at Dehra Dun showed the former to be the more successful, as transplanting checks the growth to some extent. It was found that transplanting could be carried out successfully either by pruning the root and stem or by leaving them intact; in the latter case it is advisable to use small plants during the first rainy season, owing to the length of taproot. If pruning is carried out the stem should be cut down to about 2 in. from ground-level and the taproot pruned to a length of about 9 in. The seed may be sown in the nursery in March–April in drills not less than 9 in. apart, the beds being watered regularly but moderately and kept well weeded; the young plants will be ready to transplant early in the rainy season.

For direct sowings the Dehra Dun experiments showed that line sowings on well-loosened soil, the lines being kept weeded from the commencement, gave the best results. Irrigation stimulates the growth, the seed being sown along the base of the ridge of loose earth thrown up alongside an irrigation channel $1\frac{1}{2}$ ft. by $1\frac{1}{2}$ ft. in section. In line sowings the seedlings require to be thinned out regularly.

Mr. L. S. Osmaston [1] has described some experiments carried out in 1905 and 1906, in raising *Albizzia Lebbek* artificially on shallow soil overlying trap in the Nasik district of Bombay, where the rainfall is about 24 in. The experiments and their results were briefly as follows :

1. Broadcasting without previous preparation of the soil. Seedlings of 1905 died ; those which failed to germinate in 1905 germinated in 1906, but the results in the latter case have not been recorded.

2. Dibbling : results similar.

3. Sowing on circular mounds :

(*a*) Large mounds $2\frac{1}{4}$ ft. high, 2 ft. diameter at top, and 7 ft. at base ; percentage of successful mounds, 100.

(*b*) Medium mounds 1 ft. to $1\frac{1}{4}$ ft. high, 2 ft. at top and 4 ft. at base ; percentage of successful mounds, 89·4.

(*c*) Small mounds 9 in. high, 3 ft. diameter at base ; percentage of successful mounds, 100.

4. Sowings in pits :

(*a*) All soil returned to pit ; percentage of successful pits, 37.

(*b*) Pits half filled with soil ; percentage of successful pits, 68.

(*c*) No soil returned to pit ; percentage of successful pits, 43.

5. Planting one-year-old transplants ; only 300 survived out of 7,000, or 4·3 per cent.

Mr. Osmaston further describes the conduct of line sowings in conjunction with the raising of field crops in the same locality : [2] this system, which is explained under *Acacia arabica* (p. 437), proved quite successful, the plants in $3\frac{1}{2}$ years reaching a maximum height and girth of 18 ft. and 1 ft. $5\frac{1}{2}$ in. respectively. The Berar system, described under *Acacia arabica* (p. 435), should also prove suitable for the raising of *Albizzia Lebbek.*

Mound sowings have proved successful in the Bellary district, Madras. The tree grows readily from cuttings.

Silvicultural treatment. As the tree occurs scattered in mixed forests it is in actual practice treated along with other species, usually either as coppice-with-standards or under selection fellings. In the Andaman forests it is regarded as one of the more valuable species ; under the existing working plan these forests are worked by selection fellings, the minimum girth limit for the felling of sound *Albizzia Lebbek* being fixed at 6 ft.

As a general rule natural reproduction is so scanty that the only means of ensuring a plentiful and regular supply of this timber would appear to be by artificial cultivation.

Rate of growth. The growth is fast. The rapid development of young plants under favourable conditions has already been alluded to under 'the

[1] Ind. Forester, xxxiii (1907), p. 177.
[2] *Ibid.*, p. 265.

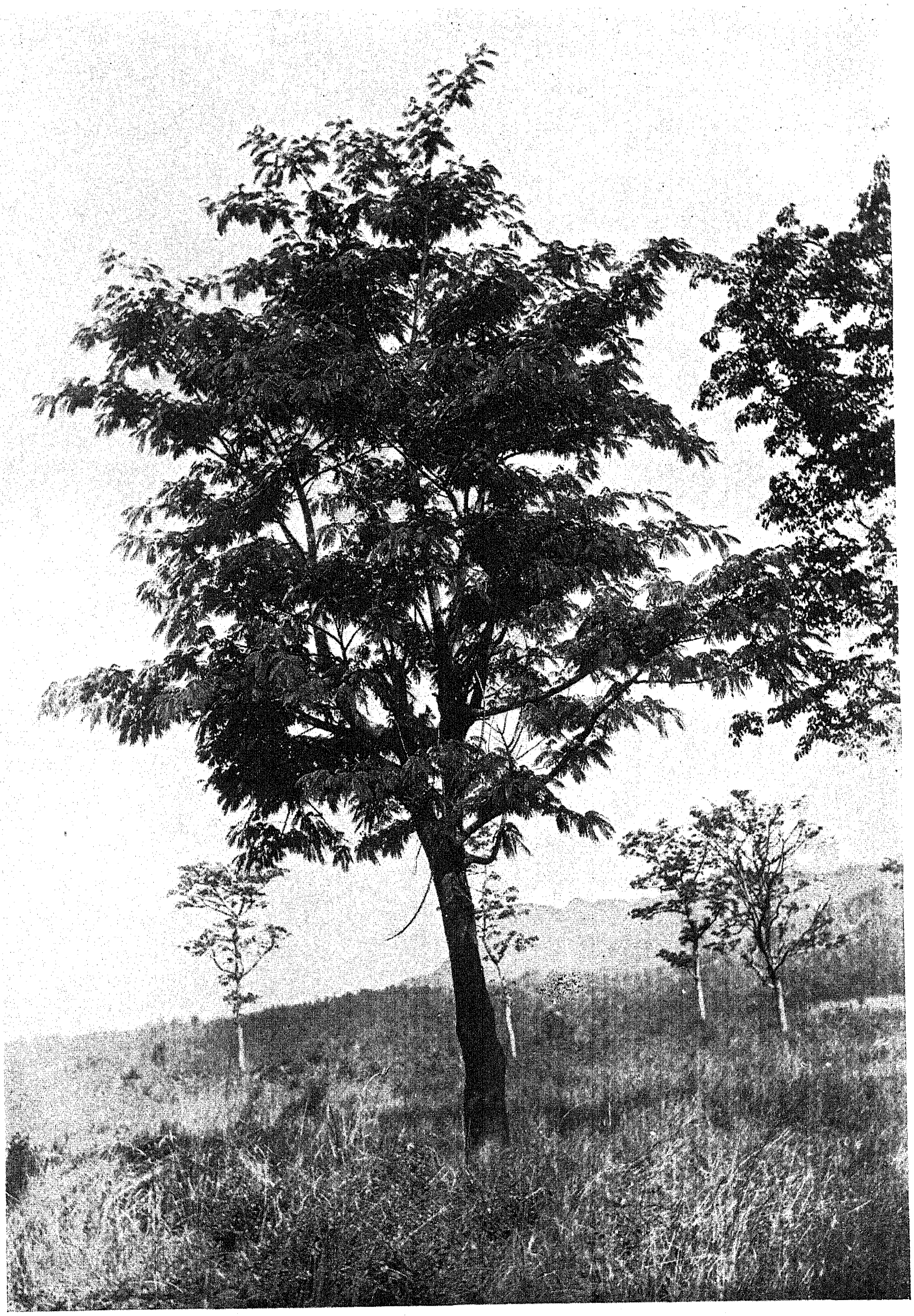

FIG. 179. *Albizzia stipulata*, United Provinces.

Fig. 180. *Albizzia procera* growing gregariously on low-level savannah, Goalpara, Assam ; *Bombax malabaricum* on extreme left.

seedling'. Brandis says that trees in the Punjab reach a girth of 2 ft. 9 in. in twelve years and 4 ft. 6 in. in thirty years, and that trees seventeen years old at Sukkur in Sind reached a girth of 5 to 6 ft. These figures probably refer to trees grown in more or less open positions; in the forest the growth in girth would probably be slower.

2. **Albizzia stipulata,** Boivin. Vern. *Ohi,* Pb.; *Siran,* Hind.; *Chakua,* Beng.; *Sau,* Ass.; *Kalbage,* Kan.; *Laeli,* Mar.; *Konda chigara,* Tel.; *Pili vagai,* Tam.; *Bônmeza,* Burm. (Fig. 179.)

A large deciduous tree with feathery foliage and large stipules. The crown is often spreading and flat-topped. Bark dark grey, fairly smooth, with occasional prominent horizontal wrinkles and furrows and numerous small vertical wrinkles. Sapwood large, white; heartwood brown, soft, not very durable, used for building, furniture, domestic utensils, &c. It is used as a shade tree in tea plantations in Assam and the Bengal Duars.

DISTRIBUTION AND HABITAT. Throughout the sub-Himalayan tract and Himalayan valleys up to 4,000 ft., Bengal, Assam, Chota Nagpur, the moister parts of the Indian Peninsula, Andamans, Nicobars, Burma, Ceylon, and the Malay Peninsula.

The tree occurs chiefly in moist localities. It is common in the Kangra valley. In the sub-Himalayan tract and outer valleys it often occurs in swampy ground and moist low-lying savannahs. In the Peninsula it is found only in the moister regions, both on the west coast and in southern India. Bourdillon says it is very common in the lower open and deciduous forests of Travancore, ascending the hills to 3,000 ft. It occurs in the evergreen *sholas* of North Coimbatore (C. E. C. Fischer). Mr. F. H. Todd mentions it as one of the species in the semi-evergreen and deciduous forests of the North Andaman.[1] In Burma it is common in the tropical forests, in mixed forests both of moist and of dry types, and extends into the hill forests. Kurz [2] mentions it as one of the lofty deciduous trees towering above the stratum of evergreen trees in closed tropical forests. He also gives it as one of the trees of the pine (*Pinus Khasya*) forests of the hills, with *Daphnidium, Aperula, Helicia, Engelhardtia, Dillenia aurea, Ternstroemia japonica,* &c., and of the lower drier hill forests, of a rather stunted type, occupying exposed ridges at 3,000 to 4,000 ft. and upwards, associated with *Ternstroëmia japonica, Schima Noronhae, Turpinia nepalensis, Bucklandia populnea, Dillenia aurea, Symplocos,* laurels, &c.

In its natural habitat the absolute maximum shade temperature varies from 95° to 110° F., the absolute minimum from 30° to 65° F., and the normal rainfall from 45 to 200 in. or more.

LEAF-SHEDDING, FLOWERING, AND FRUITING. Kurz [3] and Haines [4] say the tree is evergreen. In northern India it is deciduous, the leaves commencing to fall about January, shrivelling up and falling by single leaflets or by whole pinnae. The trees are usually leafless in February–March, the new leaves appearing in March or early April.

The masses of fragrant feathery yellowish white flowers appear from April to June amongst the rich green of the new foliage, and the tree is then

[1] Draft Working Plan for the Forests of the North Andaman, 1906.

[2] Preliminary Forest Report of Pegu, 1875.

[3] For. Flora Br. Burma.

[4] For. Flora Chota Nagpur.

particularly handsome. The pods while developing are pale reddish green: they commence ripening about November–December, and continue hanging in quantity through the leafless season, when they resemble small siris pods on the trees. They commence falling in quantity about March, and continue falling during the hot weather months, being blown to some distance from the trees by the dry winds: a few old empty pods may sometimes be found on the trees as late as September.

The pods (Fig. 181, *a*) are 3·5–6 in. long by 0·5–0·8 in. broad, flat, glabrous, light brown, often wrinkled over the seeds, 8- to 12-seeded. The majority of the pods dehisce after falling to the ground, the seed thus being distributed by the wind; only those which remain late on the tree dehisce before falling. The seeds (Fig. 181, *b*) are 0·15–0·3 in. long, flat, ovate or elliptical, greenish brown, smooth; about 900 weigh 1 oz. Tests at Dehra Dun have shown that the seed retains its vitality to some extent for at least a year, though the percentage of fertility of seed so kept is less than that of fresh seed.

GERMINATION (Fig. 181, *c–e*). Epigeous. After the emergence of the radicle the hypocotyl arches slightly, soon straightening and raising the cotyledons above ground. The testa is usually carried up over the cotyledons, falling with their expansion.

THE SEEDLING (Fig. 181).

Roots: primary root moderately long and thick, terete, tapering, wiry, white turning brown: lateral roots numerous, moderately long, fibrous, distributed down main root: nodules present. *Hypocotyl* distinct from root, 0·6–1·5 in. long, cylindrical or tapering upwards, expanded in a ring at the base, green or pinkish when young, minutely pubescent. *Cotyledons* sessile or very shortly petiolate, 0·3–0·4 in. by 0·15–0·2 in., elliptical or ovate, plano-convex, or slightly concave beneath, thin, somewhat fleshy, apex rounded, base sagittate, entire, glabrous. *Stem* erect, slightly zigzag at the nodes, green, minutely pubescent; internodes 0·2–0·5 in. long. *Leaves*, first two sub-opposite or alternate, subsequent leaves alternate. Stipules 0·1–0·15 in. by 0·1 in. or less, falcate acuminate, caducous. First leaf usually once pinnate, sometimes bipinnate; if once pinnate rachis 0·4–0·6 in. long, with about five pairs of leaflets 0·1–0·2 in. by less than 0·1 in., obliquely oblong or falcate, acute, entire, pubescent, glaucous beneath, midrib close to and parallel to one edge; subsequent leaves bipinnate, first few with one pair, then a few with two pairs, then three pairs of pinnae, leaflets 4–20 pairs, up to 0·4 by 0·15 in., rachis with a gland on the upper side.

During the first season the seedling does not show that rapid growth which is such a marked feature later on. Seedlings raised under natural conditions on unweeded and unwatered ground at Dehra Dun showed the following growth in the first two seasons:

	Under moderate shade.	In full sunlight.
Height at end of 1st season	Chiefly 5–7 in.	Chiefly 5–8 in.
Height at end of 2nd season	Maximum 4 ft.	1 ft. 3 in.–4 ft. 9 in.

The seedlings stand moderate shade, but are killed by dense shade. They are capable of struggling well through a moderate growth of weeds and grass, though their development is stimulated by regular weeding as well as watering: seedlings regularly weeded and watered reached a height of 3 ft. by the end of the first season. Weeding, however, has to be carried out from the commencement, since if weeds are suddenly removed from over young seedlings

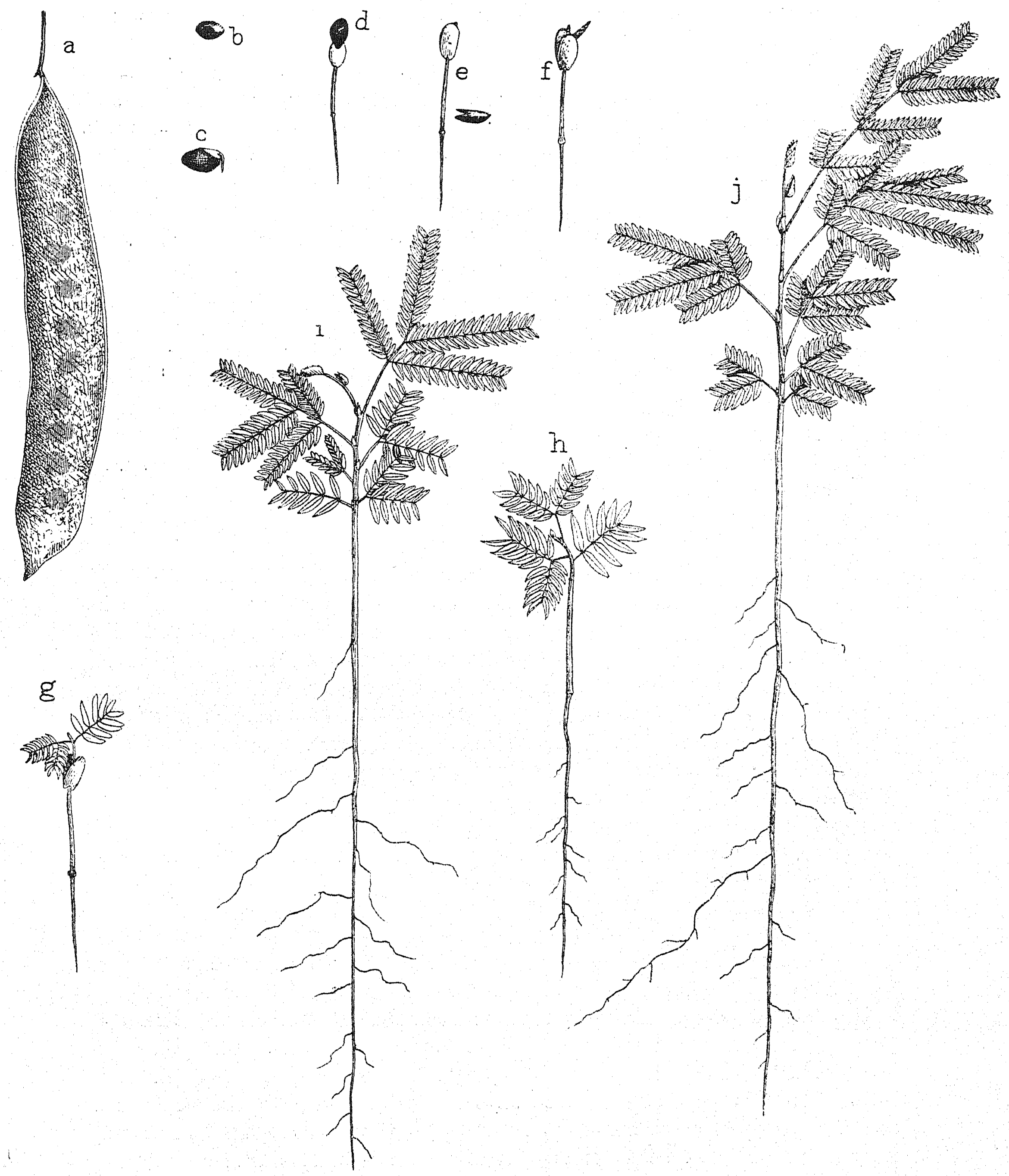

FIG. 181. *Albizzia stipulata.* Seedling × $\frac{5}{8}$.

a, fruit; *b*, seed; *c–e*, germination stages; *f–j*, development of seedling during first season.

they are apt to die of drought. The seedlings are very sensitive to drought; they are also somewhat sensitive to frost, though they have good power of recovery if killed back.

SILVICULTURAL CHARACTERS. Little is known of the silvicultural characters of this tree. It may be classed as a moderate light-demander; that it is able to stand some shade is evident from the fact that it sometimes grows up in teak plantations in Burma and makes its way through the teak.

NATURAL REPRODUCTION. Germination starts early in the rainy season, and in warm sunny places is completed early. Under shade germination may continue throughout the rains and on till October or November, while some of the seed may lie dormant through the ensuing dry season, and may germinate in the second rainy season. The most favourable conditions for natural reproduction appear to be loose soil, in which the seed becomes covered during the early showers, and a fair degree of moisture. A moderate growth of grass and weeds is not harmful, though it may hinder the development of the seedlings to some extent; in dry localities it is even useful in protecting them from drought.

ARTIFICIAL REPRODUCTION. Experiments at Dehra Dun have shown that direct sowing is more successful than transplanting, and regular weeding from the commencement stimulates growth; in this respect line sowings give the best promise of success.

Transplanting can be carried out without much difficulty in the rains. The seed should be sown in the nursery about March or April in drills 9 in. apart, the beds being well watered and weeded through the dry season. The seedlings should be planted out during the rainy season; they can be transplanted successfully after pruning down the stem to near ground-level and cutting the root down to a length of about 9 in. If unpruned plants are used they should be small, otherwise the taproot gives trouble.

RATE OF GROWTH. The growth is very rapid. In teak plantations in Burma the tree grows quickly through the fast growing teak and has to be cut out periodically in thinnings. Two cross-sections in the silvicultural museum at Dehra Dun, from trees in the United Provinces, showed the following rates of growth:

(1) Age 28 years: girth 4 ft. 11 in.: mean annual girth increment 2·1 in.
(2) Age 43 years: girth 4 ft. 6 in.: mean annual girth increment 1·25 in.

Gamble's specimens gave three to four rings per inch of radius, or a mean annual girth increment of 1·57 to 2·1 in. He also quotes the following measurements:[1] 'Roxburgh says that a tree he planted in the Botanic Garden at Calcutta measured 48·5 in. in girth at 4 ft. above ground when 7 years old; this would give a rate of growth of slightly less than 1 ring per inch of radius. Stewart, in "Punjab Plants", p. 56, says that a tree in the Saharanpur Gardens was 7 ft. in girth at about 17 years of age, which gives rather over 1 ring per inch of radius. . . . A round in the Bengal Forest Museum from a young tree shows 11 rings on a mean radius of 6 in., or 1·8 rings per inch of radius.'

3. **Albizzia procera,** Benth. Syn. *Mimosa elata,* Roxb. White siris. Vern. *Safed siris, gurar,* Hind.; *Koroi,* Beng., Ass.; *Bellati,* Kan.; *Kinhai,* Mar.; *Konda vagai,* Tam.; *Chigara,* Tel.; *Sit,* Burm.

[1] Man. Ind. Timb. (1902), p. 307.

FIG. 182. *Albizzia procera*—SEEDLING × $\frac{3}{4}$

a—Seed b - e—Germination stages f - h—Development of seedling during first season

A large tree with a long clean bole, often branching at a considerable height and forming a somewhat light crown. Bark smooth, light yellowish or greenish grey, exfoliating in thin flakes, red inside. The sapwood is large, whitish, the heartwood brown with streaks of darker or lighter colour, used for house-posts, agricultural implements, &c.

DISTRIBUTION AND HABITAT. Throughout the sub-Himalayan tract, common from the Jumna eastwards, Assam, Bengal, Chota Nagpur, the Indian Peninsula, Burma, and the Andamans. The tree is found most commonly on alluvial ground along streams and in moist, even swampy places; it is particularly common in low-lying moist savannahs, as in the Duars of Bengal and Assam, in Burma and elsewhere; in such places it is often gregarious, the clean light-coloured boles being very conspicuous (see Fig. 180). It is in many localities also a common species in mixed forests, generally on moist alluvial ground. In the Dehra Dun valley it is one of the constituents of the swamp forests, along with *Trewia nudiflora*, *Ficus glomerata*, *Pterospermum acerifolium*, *Cedrela Toona*, and other swamp species.

In its natural habitat the absolute maximum shade temperature varies from 98° to 115° F., the absolute minimum from 30° to 65° F., and the normal rainfall from 40 to 200 in.

LEAF-SHEDDING, FLOWERING, AND FRUITING. The tree becomes almost leafless for a short time during the hot season, from April to June, according to locality: Haines [1] says there may be a second flush of new leaves in August growing through the flowering panicles. The large panicles of yellowish white flowers appear from June to September. The pods soon commence forming, and in the cold season, especially from October to January, they have a rich red colour, the trees at this time being particularly handsome with the masses of red pods against the green foliage. The pods ripen from February to May, and are then dark reddish brown, 4–8 in. long by 0·5–0·9 in. broad, thin, strap-shaped, 6- to 12-seeded, dehiscent. The seeds (Fig. 182, *a*) are 0·2–0·3 in. by 0·15–0·25 in., flat, elliptical to nearly orbicular, hard, smooth, greenish brown, with a leathery testa; about 500–850 weigh 1 oz.

The pods fall from the trees for the most part during the hot season, dehiscing before or about the time of falling. The seed germinates readily, and is less subject to insect attacks than that of *A. Lebbek*. It retains its vitality for at least a year; two tests of seed one year old at Dehra Dun showed 23 and 80 per cent. of fertility respectively.

GERMINATION (Fig. 182, *b–e*). Epigeous. After the emergence of the radicle the hypocotyl arches slightly, carrying the cotyledons above ground; the testa is either left on or in the ground, or, less commonly, carried up over the cotyledons, falling with their expansion.

THE SEEDLING (Fig. 182).

Roots: primary root long, at first thin, becoming fairly thick in vigorous plants, terete, tapering, wiry, whitish at first, becoming yellow or light brown: lateral roots few, somewhat short, fibrous, distributed down main root: nodules present. *Hypocotyl* distinct from root, 1·2–2 in. long, cylindrical, green or pinkish. *Cotyledons* sessile or sub-sessile, 0·35–0·4 in. by 0·2 in., elliptical, flat, somewhat fleshy, base sagittate, entire, green, glabrous. *Stem* erect, terete, wiry; internodes 0·2–1·5 in. long. *Leaves* alternate, compound.

[1] For. Flora Chota Nagpur.

Stipules minute, linear. First leaf compound, paripinnate, with rachis 0·6–1 in. long, terminating in a bristle, leaflets normally three pairs, opposite, shortly petioled, 0·4–0·6 in. by 0·15–0·25 in., obliquely ovate or obovate oblong, acute or obtuse, glabrous. Subsequent leaves bipinnate, leaves of the first season with one pair of pinnae, the number of pairs increasing later ; common rachis and pinnae each 0·5–2 in. long ; leaflets at first two or three pairs on each pinna, the number increasing to about ten pairs during the first season, opposite or sub-opposite, up to 1 in. by 0·3 in.

Under natural conditions the seedling usually attains a height of 4–8 in. by the end of the first season, but if regularly weeded and watered it grows rapidly, nursery-raised seedlings at Dehra Dun having attained a height of 1 ft. to 1 ft. 8 in. in three months from germination. The seedling is capable of struggling during the first season through low weeds and grass, its growth being slow during the process but increasing considerably after the weeds have been surmounted. The sudden removal of weeds from around seedlings previously unweeded, however, is liable to cause their death through sudden exposure to the sun. Vigorous seedlings produce long stout taproots which may reach a length of nearly 2 ft. in three months from germination : the lateral rootlets are usually covered with nodules.

The following measurements of seedlings in various plots at Dehra Dun will give some idea of the rate of growth under different conditions :

Albizzia procera : development of seedlings.

Conditions under which grown.	Height at end of season. 1st season.	2nd season.	3rd season.	4th season.
Nursery-raised transplants, entire stem and roots	(1) Maximum 0 ft. 6 in. (2) ,, 1 ft. 4 in.	(1) 1 ft. 2 in.–3 ft. 4 in. (2) Maximum 3 ft. 1 in.	(1) 1 ft. 9 in.–7 ft. 5 in.	
Nursery-raised transplants, pruned stem and roots	Maximum 1 ft. 0 in.	Maximum 4 ft. 2 in.	2 ft. 10 in.–8 ft. 5 in.	
Natural conditions, unweeded, in full sunlight	(1) Maximum 0 ft. 6 in. (2) 4 in.–7½ in.	(1) Maximum 2 ft. 1 in. (2) 1 ft. 6 in.–2 ft. 5 in.	(2) 2 ft. 4 in.–8 ft. 2 in.	(2) Maximum 11 ft. 6 in.
Natural conditions, unweeded, in moderate side shade	(1) Maximum 0 ft. 6 in. (2) ,, 0 ft. 7½ in.	(1) 5½ in.–1 ft. 10 in. (2) 9 in.–1 ft. 8 in.		

The growth would in most cases have been greater except for the damage caused by the hemipterous insect *Oxyrhachis tarandus*, Fabr., which causes much injury to this species, as in the case of *Albizzia Lebbek*. The seedlings are somewhat frost-tender, and are liable to be killed back in frosty localities. Growth ceases about November, and recommences about February–March. The leaves drop from December to February and the seedling is leafless for a short time.

SILVICULTURAL CHARACTERS. Although it stands moderate but not heavy shade in youth the tree may be classed as a light-demander, as it cannot stand suppression. In the abnormal drought of 1907 and 1908 in Oudh it proved fairly drought resistant, though in the moist localities in which it grows it was probably not as severely tested as species growing in drier tracts. In the great frost of 1905 in northern India it suffered severely. The tree is much subject to cankerous wounds, as a rule where branches have been broken

off. Mr. G. M. Ryan,[1] writing of conditions in Bombay, says the tree throws up root-suckers when the aerial portion of the stem has been mutilated or when an advanced age has been reached.

NATURAL REPRODUCTION. The natural reproduction of this tree is far more satisfactory than that of *A. Lebbek*. Germination takes place readily provided there is sufficient moisture, and in the forest seedlings may be found in quantity in the neighbourhood of seed-bearers during the rainy season, from seed which germinated early in the rains. Although the seed germinates more readily than that of *A. Lebbek*, in densely shaded localities the seedlings quickly die off, while in such places some of the seed may lie ungerminated until the second rains. The factors most favourable to natural reproduction are plentiful moisture and bare loose soil where the seed becomes buried with the early showers. Thus on new soft alluvial ground near rivers seedlings in all stages may often be found in abundance. Natural seedlings may also be found in some quantity in moist grassy tracts.

ARTIFICIAL REPRODUCTION. Experiments carried out at Dehra Dun have shown that transplanting can be carried out successfully in the rainy season, preferably during wet weather, with stem and root either pruned or left intact, but in the latter case transplanting is troublesome unless small plants of the first season are used. The seeds should be sown in nursery beds about March to May in drills about 9 in. apart, the seeds being placed a few inches apart in the drills and lightly covered.

Direct sowing has proved more successful than transplanting, provided regular weeding and loosening of the soil is carried out; line sowings have given greater success than any other form of sowing owing to the facility with which weeding can be carried out. This is a suitable species for growing in irrigated plantations or in line sowings in conjunction with the raising of field crops.

The tree grows readily from cuttings.

SILVICULTURAL TREATMENT. The tree is a useful one for afforesting low-lying savannahs and moist alluvial tracts. Although natural reproduction is often good near seed-bearers artificial reproduction would have to be relied on for complete stocking.

RATE OF GROWTH. The rate of growth is rapid. A cross-section in the silvicultural museum at Dehra Dun showed 26 rings for a girth, including bark, of 3 ft., giving a mean annual girth increment of 1·38 in. Brandis says that in northern India it attains a girth of 3–4 ft. in twelve years and 4–6 ft. in thirty years, giving a mean annual girth increment of 1·6 to 4 in. Gamble's specimens gave 6 rings per inch of radius, representing a mean annual girth increment of about 1 in.

4. **Albizzia odoratissima,** Benth. Syn. *Mimosa odoratissima*, Roxb. Black siris. Vern. *Karmaru*, Pb.; *Kali siris, bansa* (C. P.), Hind.; *Bilkumbi, bilwara*, Kan.; *Karu vagai*, Tam.; *Thitmagyi*, Burm.

A large tree with graceful drooping dark green foliage. Bark grey to yellowish grey, dark crimson inside. The dark brown heartwood is used for building, carts, wheels, furniture, &c. Haines[2] recognizes a variety *A. lebbekifolia* in the Central Provinces, with foliage very like *A. Lebbek* but distinguishable by the short peduncles, sessile flowers, and colour of the pods.

[1] Ind. Forester, xxx (1904), p. 454. [2] *Ibid.*, xl (1914), p. 227.

Distribution and habitat. Sub-Himalayan tract and slopes and valleys of the Himalaya up to 5,000 ft., Bengal, Chota Nagpur, the Indian Peninsula, and Burma; also in the low country of Ceylon. The tree is widely distributed, being a common constituent of many types of mixed deciduous forest, where it grows sporadically. It is frequently found on hill slopes, and sometimes in valleys. In northern India it is common in the outer Himalaya and in the Siwalik hills: it extends throughout the greater part of the Indian Peninsula in dry as well as in moist deciduous forests. In Ajmer-Merwara it is one of the most important species, growing in dry forests on hill slopes with *Anogeissus pendula*, *Acacia Catechu*, *Boswellia serrata*, and other trees. In Burma it is common in the upper mixed forests with teak and its associates, extending into the drier types where the teak is associated with *Pentacme suavis*, *Shorea obtusa*, *Dalbergia cultrata*, *Phyllanthus Emblica*, &c. In Bombay it is common in the moist monsoon forests of North Kanara and the Konkan and also in the dry Deccan, ascending to 3,700 ft. in the Khandesh Akrani (Talbot). Bourdillon says it is common on grass-lands and in open forest throughout Travancore up to 3,000 ft.

In its natural habitat the absolute maximum shade temperature varies from 100° to 120° F., the absolute minimum from 30° to 60° F., and the normal rainfall from 25 to 120 in.

Leaf-shedding, flowering, and fruiting. The leaves commence falling about December (northern India), and the new leaves appear in March–April. The tree sometimes becomes quite leafless for some little time, but more commonly the new leaves appear before the old ones have all fallen. The pale yellowish white fragrant flower-heads in large terminal panicles appear from April to June, and by October the pods are full-sized but still green: they commence ripening in December (northern India), or earlier farther south, falling during the hot season and dehiscing as a rule after falling, though some may hang for a long time on the tree, dehiscing before falling. When ripe the pods are 5–12 in. long by 1–1·3 in. broad, reddish brown or purplish green with darker markings over the seeds, flat and flexible, eight- to twelve-seeded.

Silvicultural characters. The tree stands a certain amount of shade in youth, but may be classed as a moderate light-demander. It is not exacting as regards soil, though on poor soil it is somewhat stunted. Its roots are largely superficial, and numerous root-suckers are produced. The young plants are susceptible to frost, and plantations formed in Ajmer-Merwara are reported to have failed for this reason. The tree coppices well, and in Ajmer-Merwara the shoots are said to reach a height of 10 ft. in two years, but are liable to be killed by frost: natural seedlings are reported to be plentiful in sheltered places where the soil is good.[1]

Rate of growth. The only measurements available are those recorded by Mr. Gamble from wood specimens examined by him, the average of which showed 4 rings per inch of radius or a mean annual girth increment of 1·57 in.

5. **Albizzia lucida,** Benth. Burmese siris. Vern. *Thanthat,* Burm.

A large tree with thin greyish bark and a full crown of handsome dark green foliage, the leaflets fewer and larger than in other species of this genus.

[1] Working Plan for the State Forests of Ajmer-Merwara, 1896.

Distribution and habitat. The sub-Himalayan tract from Nepal eastwards, eastern Himalayan valleys up to 2,000 ft., Assam, Chittagong, and Burma. The tree is often planted along avenues and in gardens outside its natural region, and grows well in Dehra Dun and other stations of northern India. It is found wild as a rule along the banks of streams and in moist places. In Burma it occurs in tropical forests where many of the species are evergreen, in lower mixed forests of the alluvial plains, and also in upper mixed deciduous forests.

In its natural habitat the absolute maximum shade temperature varies from 98° to 108° F., the absolute minimum from 35° to 55° F., and the normal rainfall from 45 to 200 in. or more.

Leaf-shedding, flowering, and fruiting. The tree is leafless or nearly so for a short time in the early part of the hot season, about March; the leaves usually turn yellow before falling. The yellowish white flowers appear in April–May. The pods become full-sized about October–November, but are then unripe and green or reddish green; they ripen from February to April (observed ripening February in Bengal Duars, April in Dehra Dun). When ripe (Fig. 183, *a*) they are 4–8 in. long by 0·7–1 in. broad, light brown, flat, the seeds prominent. Most of the pods fall during the hot season, and dehisce as a rule after falling: they are carried by wind, with the seeds enclosed, to some distance from the tree. Some dehisce on the tree and a few of the open pod-valves may remain hanging as late as the following November. The seeds (Fig. 183, *b*) are 0·3–0·4 in. long, broadly elliptical or orbicular, light brown, flat, smooth, with a leathery testa: about 550–600 weigh 1 oz. The seeds germinate readily, but so far as tests at Dehra Dun go they appear to lose their vitality more quickly than those of other species of *Albizzia*.

Germination (Fig. 183, *c–g*). Epigeous. After the emergence of the radicle the hypocotyl arches, soon straightening and carrying the cotyledons above ground: as a rule the testa is carried up over the cotyledons, falling off with their expansion.

The seedling (Fig. 183).

Roots: primary root moderately long, terete, tapering, flexuose: lateral roots moderate in number, fibrous, distributed down main root. *Hypocotyl* distinct from and thicker than young root, 1·2–1·8 in. long, terete, tapering slightly upwards, green, minutely pubescent. *Cotyledons* sub-sessile, 3·5–5 in. by 3–4 in., plano-convex, fleshy, elliptical orbicular, base sagittate, entire, glabrous, greenish yellow. *Stem* erect, wiry to woody. *Leaves*, first pair opposite, produced after a very short internode, thus emerging from between the cotyledons, subsequent leaves alternate. First pair simple or paripinnate with two or three pairs of leaflets or imparipinnate with five leaflets or bipinnate, one of the leaves often differing in form from the other. Simple leaves with petiole 0·1 in. long, lamina 0·8–1·2 in. by 0·3–0·4 in., ovate or elliptical lanceolate, acuminate, entire, glabrescent or minutely pubescent. Earliest compound leaves with rachis 0·5–0·8 in. long, leaflets opposite, very shortly petiolate, 0·5–0·8 in. by 0·2–0·4 in., ovate lanceolate, acuminate.

Seedlings raised at Dehra Dun showed only moderate growth during the first two years, nursery-raised transplants having a maximum height of 5½ in. and 14 in. by the end of the first and second seasons respectively. The seedlings proved very sensitive to drought, and grew best if well watered and kept shaded from the sun.

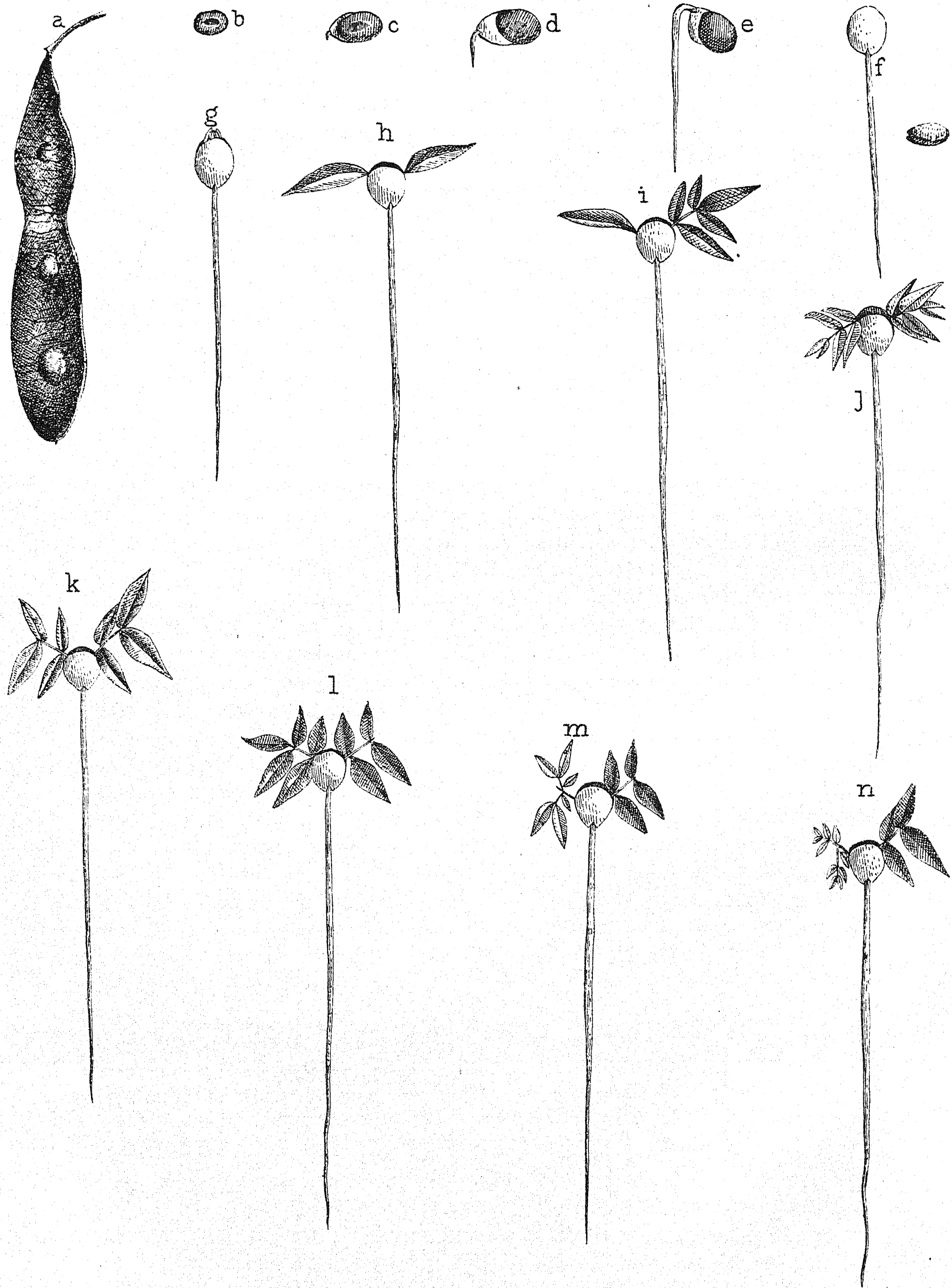

FIG. 183. *Albizzia lucida*. Seedling × $\frac{5}{8}$.
a, fruit; *b*, seed; *c–g*, germination stages; *h–n*, early seedling stages showing variations in leaves.

SILVICULTURAL CHARACTERS. The silvicultural characters of this tree have not been studied in detail. It appears to be somewhat shade-bearing, and requires a moist situation for its best development. It has long spreading lateral roots near the surface of the ground, which produce a prolific crop of root-suckers to a considerable distance from the tree.

ARTIFICIAL REPRODUCTION. Experiments at Dehra Dun have shown that transplanting can be done without much difficulty both in the first and in the second rainy season, though this should be carried out as far as possible in wet weather. Fresh seed should be sown in the nursery-beds about March or April, the beds being kept well watered and weeded and shaded from the sun during the heat of the day. The transplanting of root-suckers is also recommended.

6. **Albizzia amara,** Boivin. Syn. *Mimosa amara,* Roxb. Vern. *Tugli, tugal,* Kan. ; *Lallei,* Deccan ; *Chikreni,* Tel. ; *Thuringi, unjai, usil,* Tam.

A small or moderate-sized much-branched deciduous tree with thin smooth dark greenish scaly bark. The leaves have numerous small leaflets. Heart-wood purplish brown, very hard, used for small building material, agricultural implements, &c., but chiefly for fuel.

A tree of the Indian Peninsula from Khandesh and Vizagapatam southwards, on dry often hilly country. Dry regions of Ceylon. On the Laun sandstone plateau in Raipur, Central Provinces (Haines). It is a common tree in the dry mixed deciduous and thorn forests of the Deccan. It is one of the most characteristic trees in the dry regions of the Madras Presidency, often growing on very poor soil ; among its chief companions are *Acacia Latronum, A. Catechu, A. planifrons, A. leucophloea, Chloroxylon Swietenia, Dichrostachys cinerea, Azadirachta indica, Anogeissus latifolia, Prosopis spicigera, Cassia Fistula, Strychnos Nux-vomica, S. potatorum, Phyllanthus Emblica, Cleistanthus collinus, Terminalia Chebula, Zizyphus Xylopyrus,* and *Wrightia tinctoria.*

The tree reproduces freely from coppice-shoots and also produces root-suckers ; the coppice-shoots are often produced in such numbers that their size suffers and thinning is necessary. Natural reproduction by seed is usually good in areas protected from fire and grazing : goats are very partial to it, and it suffers much in grazed areas. The tree is usually worked as coppice or coppice-with-standards. It has been roughly estimated that coppice-shoots attain a girth of 2½ ft. in thirty years.[1]

The yellow fragrant flower-heads appear from April to June and the pods ripen in the cold season, chiefly from November to January. The pods are 5–8 in. by 0·7–1 in., thin, flat, greyish brown, pubescent, veined, with undulate edges.

7. **Albizzia mollis,** Boivin. Syn. *A. Julibrissin,* Durazzini. Pink siris, hill siris. Vern. *Sirín, lal siris, kurmura,* Hind.

A moderate-sized tree of the western Himalaya, ascending to 7,000 ft. The tree reproduces freely from root-suckers, and is useful for afforesting unstable hill-sides. The large pink tassels of flowers appear from April to June, at which time the tree is very handsome. The pods ripen from September to November, and remain some time on the tree : they are 3–5 in. by 0·6–0·9 in.,

[1] Tiruvannamalai Working Plan, South Arcot, 1902.

thin, yellow or light brown, eight- to twelve-seeded. The growth is fast; Gamble's specimens showed 3–4 rings per inch of radius, which gives a mean annual girth increment of 1·57 to 2·1 in.

8. **Albizzia moluccana,** Miq.

A very large fast-growing Malayan tree with light foliage and a straight clean smooth grey bole, branching high up. It is largely grown in Ceylon and Java as a shade to coffee, and is worth cultivating as a quick-growing shade tree for other crops requiring light shade, as it is said to possess soil-improving properties. It has recently been grown on land cleared for tea in Assam, where in the Towkok garden, Sonari, Sibsagar district, trees four years from seed were reported in 1913 to have grown 46 ft. in height with a girth of 2 ft. 9 in. at 3 ft. from ground-level. Plantations of this tree have recently been formed in the Andamans, where it grows well even in exposed situations and is not affected by wind. Plants from seed sown in December 1912 attained by 1916 a height of 30 to 35 ft. and a girth of 1½ to 2 ft.; those on the soil of cleared evergreen forest attained in the same time a height of 40 to 45 ft. and a girth of 2–3 ft. at 3 ft. from ground-level. A tree in the Royal Botanic Gardens, Peradeniya, Ceylon, eleven years old, was 125 ft. high and nearly 11 ft. in girth at 2 ft. from the ground.[1] In Ceylon the pods ripen in May–June; the seeds are small, about 1,200 weighing 1 oz. The wood is soft and light, and suitable for tea-boxes and planking. Owing to its rapid growth it should be worth planting for this purpose in suitable localities.

5. DICHROSTACHYS, DC.

Dichrostachys cinerea, W. and A.

A thorny shrub or small tree with brown or grey longitudinally furrowed bark, found on dry stony ground in central and southern India, Rajputana, the Deccan and the dry zone of Upper Burma. It occurs also in Tinnevelly, along with *Acacia planifrons*, on land regularly inundated by sea-water during the north-east monsoon, forming a dense impenetrable growth. In the dry regions in which it is commonly found the forest is usually of an open scrubby nature, situated both on hilly and on flat ground. In the Central Provinces it is frequent on black cotton soil. Silviculturally its chief importance in dry regions lies in the fact that it is very drought-resisting and reproduces freely by root-suckers, which are often produced at a considerable distance from the main stem owing to the long spreading lateral roots: thickets many yards in diameter are formed in this way. It is also comparatively immune from damage by grazing.

The plant resembles an acacia, having bipinnate leaves with minute leaflets. The inflorescences are striking, consisting of cylindrical spikes of flowers, the upper ones yellow and bisexual and the lower ones rose-coloured and sterile with long staminodes. The pods are 2–3 in. long, curled and twisted. The flowers appear and the fruit ripens at various times according to locality, during the hot season, the rains, or the cold season.

[1] Cir. and Agr. Journ. Roy. Bot. Gardens, Ceylon, Ser. I, No. 18, July 1900.

6. ADENANTHERA, Linn.

Adenanthera pavonina, Linn. Vern. *Munjuti*, Kan.; *Anei, kundumani*, Tam.; *Ywegyi*, Burm.

A handsome deciduous tree of the eastern sub-Himalayan tract, Burma, the Andamans, and the Western Ghats, often planted for ornament, especially in southern India. It attains a height of about 60 ft. The red wood is used for cabinet work and the scarlet seeds are used for jewellers' weights and necklaces. The tree requires a moist climate to thrive well, and can be grown easily from large cuttings put down early in the rains. The seeds are hard, and germinate with some difficulty unless kept moist for some days prior to sowing. The tree is leafless for a short time during the cold season. The small yellow fragrant flowers appear in the hot season. The pods are linear, narrow, about 6–8 in. long, twisting while opening and exposing the red seeds.

7. PITHECOLOBIUM, Martius.

Species 1. *P. dulce*, Benth.; 2. *P. Saman*, Benth.

1. **Pithecolobium dulce**, Benth. Syn. *Inga dulcis*, Willd.; *Mimosa dulcis*, Roxb.

A moderate-sized evergreen tree with stipular spines in pairs, a native of Mexico but commonly cultivated in India and Lower Burma as a hedge plant, and in southern India also as a fuel tree. On the coast of the Nellore district of Madras it has been planted on pure sand in the casuarina plantations as a safeguard against fungus disease in the casuarina. For hedges it is usual to sow the seed at site, and to trim the plants. The small globular heads of white flowers appear in January–February and the pods ripen from April to June; the latter are 4–5 in. long by 0·3–0·4 in. broad, twisted, with black seeds embedded in a spongy edible pulp. The growth is fast. The tree coppices vigorously, and stands a good deal of shade. Parker[1] gives the following note regarding its susceptibility to frost in the Punjab:

'In Lahore it suffers considerably from frost. Seedlings planted in the Changa Manga Rest House Garden grown from seed received in 1912 from Sonora, Mexico, were uninjured by three nights' frost when the shade temperature sank to 27°, 27°, 26° F., although they were only a foot or so high and were quite unprotected. In 1914–15 plants from Indian seed were killed by frost in Lahore, but plants from Sonoran seed were uninjured, though they were not protected in any way. Hence it appears that the Sonora plant is a more frost-hardy variety than the one hitherto grown, which has not got beyond the South and Eastern portions of the Province owing to frost.'

2. **Pithecolobium Saman**, Benth. Rain tree.

A large tree with a broad spreading crown, branching low down and forming a short bole. A native of tropical South America, it has been largely planted along roadsides in some of the warmer parts of India, and particularly in Lower Burma, where it is one of the commonest roadside trees. It will not stand the colder parts of northern India, but elsewhere it is not particular as to soil, and will thrive even in comparatively dry climates, as at Mandalay, though it grows best in a moist climate. In the delta districts of Burma it

[1] For. Flora Punjab, p. 201.

is capable of growing in some of the wettest places, rapidly killing out grasses with its broad crown ; it has therefore been suggested as a suitable tree for planting up grassy blanks in the fuel reserves in swampy localities, with the view of killing out grass and enabling other species of trees to be introduced afterwards. The pods contain a sweet edible pulp, and are readily eaten by cattle ; the wood, however, is of little value. In Burma the flowers with their pink tufts of stamens appear in the hot season, chiefly in April and May, and the pods ripen from March to May. The growth is very rapid, and the tree is easily raised from seed ; it can also be grown from cuttings.

8. LEUCAENA, Benth.

Leucaena glauca, Benth. Lead tree.

An unarmed evergreen large shrub or small tree, a native of tropical America and naturalized in other tropical regions of the world. It is planted in the plains of India, often as a hedge plant, and regenerates freely from self-sown seed. It occurs in the Phillaur plantation on the Punjab plains, where natural seedlings appear readily and stand a fair amount of shade. In the Philippines, where it is known as ipil-ipil, its growth in youth, according to Mr. D. M. Matthews,[1] is extremely rapid, seedling plants twenty-six months old varying from 3 to 5 cm. (1·2 to 2 in.) in diameter at breast height. It coppices vigorously and the growth of coppice-shoots is much more rapid than that of seedling plants, the shoots reaching a height of 5 m. (16·4 ft.) and a breast-height diameter of 5 cm. (2 in.) in one year. Coppice coupes one year old on well-drained soil were found to yield more than 90 stacked cubic metres per hectare (1,287 cub. ft. per acre), including brushwood of all sizes, while coupes two years old yielded up to 114 stacked cubic metres per hectare of material large enough for fuel, giving an annual production of 57 cubic metres per hectare or 815 cub. ft. per acre.

The utility of this species for afforesting grass-lands with the view of preparing the way for the introduction of timber trees has been proved in the Philippines. The dominant grass is *Imperata exaltata*, with which few species are able to compete owing to its dense mass of rhizomes and roots. The usual custom is to burn the grass immediately before the rainy season and to sow the *Leucaena* seed broadcast at the beginning of the rains : ploughing up the ground before sowing the seed is considered likely to give better results. Where seed is not sufficiently plentiful sowing in ploughed lines or transplanting from the nursery is suggested. The plant flowers and fruits at a very early age, good seed being produced by vigorous plants in the first or second year. In the Philippines the plant grows at comparatively low elevations in regions where the rainfall varies from 40 to 160 in. It is not particular as to soil, though it flourishes best on deep moist soil.

[1] Bureau of Forestry, Philippines, Bull. No. 13, 1914.

ORDER XXIV. ROSACEAE

This order is of little importance from a forest point of view, except that many of the species reproduce freely by means of root-suckers and are thus useful in clothing unstable hill-sides. This characteristic may, however, in some cases render them noxious weeds, as in the case of certain species of *Rubus* and *Rosa*, which form dense thickets in moist places, impeding the reproduction of forest trees. *Rubus lasiocarpus*, Sm., a scrambling shrub of the outer Himalaya, has an effective means of spreading by long flexible whip-like pendulous shoots which are produced in the rainy season and grow rapidly. The ends of these shoots are soft, and as soon as they come in contact with the ground they produce roots which quickly take a firm hold of the ground and in their turn produce new plants, a dense gregarious mass of interlacing brambles being formed in time. Of climbers, *Rosa moschata*, Mill., and *R. Leschenaultiana*, W. and A., deserve mention. The former is a common Himalayan species, often attaining considerable thickness and climbing to some height; although extremely handsome when in flower in the spring, it is often noxious to tree growth, causing suppression with its mass of scrambling branches and foliage. The latter is a large climber of the hills of southern India, very common in the Nilgiri *sholas*.

This order contains several important fruit trees grown in India, chiefly in the hills, namely *Prunus armeniaca*, Linn., the apricot; *P. persica*, Benth. and Hook. f., the peach; *P. communis*, Huds., the plum; *P. Amygdalus*, Baill., the almond; *P. Cerasus*, Linn., the cherry; *Pyrus Malus*, Linn., the apple; *P. communis*, Linn., the pear; and *Eriobotrya japonica*, Lindl., the loquat.

The Rosaceae are with few exceptions hill species, the majority Himalayan, several in the hills of southern India and some in Baluchistan and the hills of Assam and Burma.

Genera 1. PRUNUS, Linn.; 2. PYRUS, Linn.

1. PRUNUS, Linn.

Species 1. *P. Puddum*, Roxb; 2. *P. Padus*, Linn; 3. *P. nepalensis*, Hook. f.

1. **Prunus Puddum,** Roxb. Vern. *Padam*, Hind. Indian wild cherry.

A tree of the Himalaya, at 2,500–8,000 ft., Khasi hills and hills of Upper Burma, often cultivated. Bark greyish brown, smooth, shining, peeling off in thin horizontal strips like that of the common cherry. Gamble notes that there are two varieties of the tree in the Darjeeling hills: (1) a very large tree with crimson flowers which appear in March, and (2) a small or medium-sized tree with pink flowers which appear in October–November. The latter is the common one in the western Himalaya, both wild and cultivated. It is small or moderate-sized, producing clusters of pink flowers in the autumn or early winter, chiefly from October to December, though it occasionally flowers partially out of season, e. g. in July. The old leaves turn yellow and fall from October to December, the new flush appearing before the old ones have all fallen, and remaining fresh and green through the winter. The fruit, a yellow and red ovoid drupe 0·4–0·6 in. long, ripens chiefly from April to June. The

seeds are spread by birds. In Burma the tree is evergreen or nearly so, and this is also the case in the western Himalaya. When in flower it is very handsome. In the western Himalaya it is common in open village lands as well as in the forest. It stands a fair amount of shade, and may be found flourishing under the moderate shade of other trees, though it flowers best in the open. It reproduces fairly freely from root-suckers, and can be grown from cuttings; it forms a good stock plant for the common cherry.

2. **Prunus Padus,** Linn. Syn. *Padus cornuta*, Carr.; *Cerasus cornuta*, Wall. Bird cherry. Vern. *Páras, kalakat, zam*, Pb.; *Jamana, jamoi*, Jaunsar.

A moderate-sized or large deciduous tree with brown scaly bark. Wood with a handsome silver grain, suitable for furniture and deserving to be better known. In Europe it is usually a rather small tree, but in the Himalaya it attains a height of 60 ft. or sometimes more, and a girth of 6 ft. or over.

DISTRIBUTION AND HABITAT. This is the most widely distributed of all the species of *Prunus*, and is found throughout the greater part of Europe, in Siberia, Manchuria, North China, Japan, Persia, the Caucasus, and the Himalaya. In the Himalaya it is common chiefly at 6,000–10,000 ft., often occurring more or less gregariously on rather moist pasture grounds and in forest glades, associated with *Acer caesium*, *Aesculus indica*, *Ulmus Wallichiana*, and other broad-leaved species, as well as with conifers, particularly with yew (*Taxus baccata*), which in Hazara is often in the form of an underwood to it (see Fig. 185). It is particularly common in Hazara, where it attains very fair dimensions: on the higher ridges and grazing grounds at 9,000–10,000 ft., where it is plentiful, it is often associated with *Pyrus lanata*.

LEAF-SHEDDING, FLOWERING, AND FRUITING. The leaves turn red and fall in the autumn, the tree remaining leafless during the winter and the new leaves appearing in the spring. The racemes of small white flowers appear from April to June, and the fruits, red to nearly black drupes about 0·4 in. in diameter, ripen from August to October. Fig. 184, *a*, shows the fruit-stone. The seed is disseminated by birds, which eat the fruits.

GERMINATION (Fig. 184, *b*, *c*). Epigeous. The fruit-stone splits in two, enabling the radicle to emerge. The hypocotyl elongates, carrying the cotyledons above ground, while the two halves of the fruit-stone are left on the ground.

THE SEEDLING (Fig. 184).

Roots: primary root moderately long, wiry, flexuose: lateral roots moderate in number and length, fibrous, distributed down main root. Hypocotyl distinct from root, 1·2 in. long, terete, fusiform or tapering upwards, red, minutely pubescent and tender when young, brown, glabrous and woody in second year. *Cotyledons*: petiole very short, flattened: lamina 0·25–0·3 in. by 0·15–0·2 in., plano-convex, fleshy, elliptical or obovate, entire, glabrous. *Stem* erect, slightly compressed, minutely pubescent; first internode, above cotyledons, 0·6–1·5 in. long, subsequent internodes of first season very short, leaves being crowded together. *Leaves* simple, first pair opposite, subsequent leaves alternate or sub-opposite, approximate. Stipules 0·2–0·3 in. long, linear acuminate, fimbriate. Petiole 0·2–0·4 in. long. Lamina 1–2·5 in. by 0·5–1 in., ovate lanceolate, acute or acuminate, base acute or tapering, serrate, glabrous, venation arched, veins prominent, depressed above, raised beneath, lateral veins 7–10 pairs.

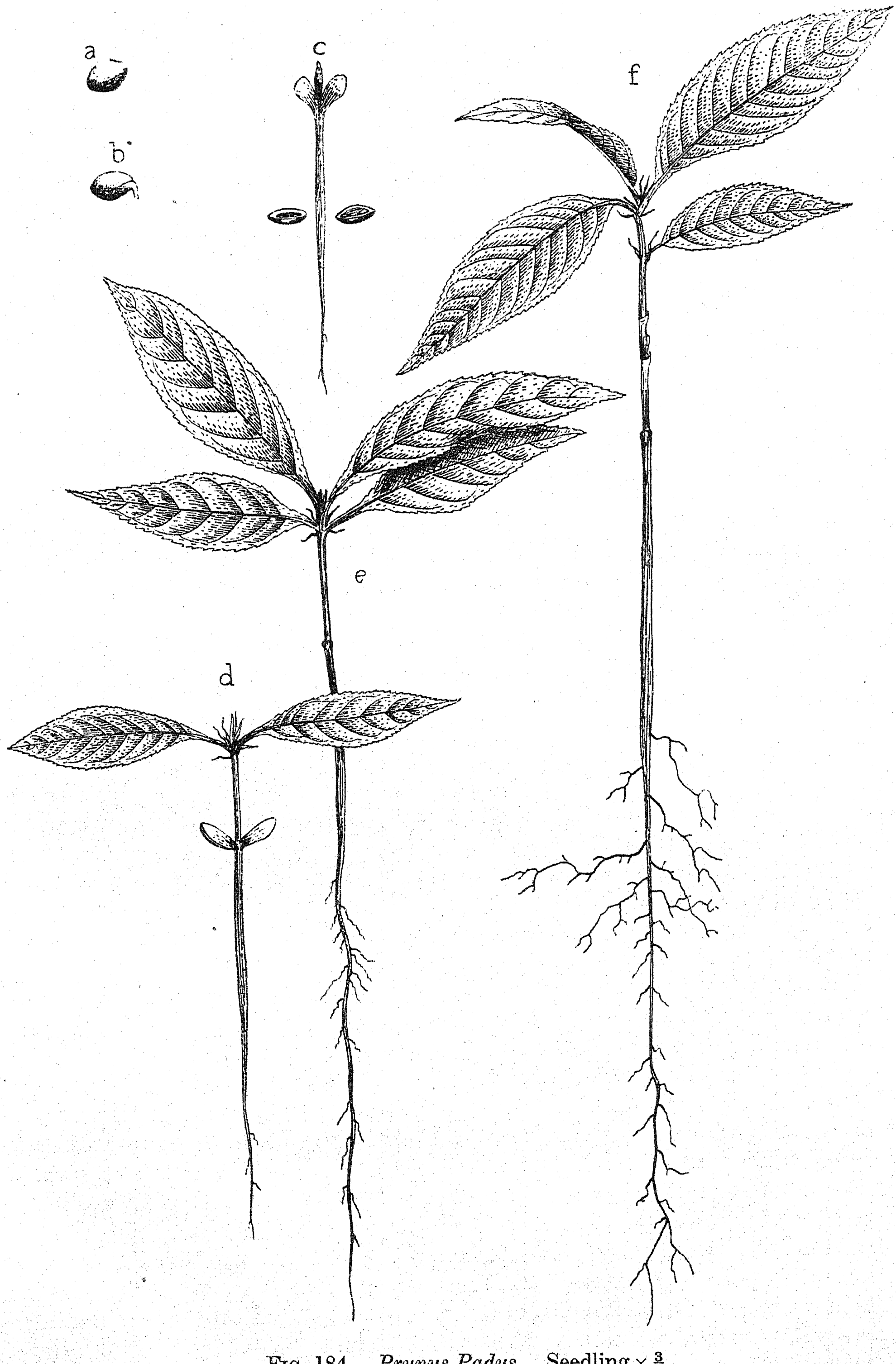

FIG. 184. *Prunus Padus*. Seedling × $\frac{3}{4}$.

a, fruit-stone; *b*, *c*, germination stages; *d*, *e*, development of seedling during first season; *f*, seedling in second season.

The growth of the seedling is somewhat slow, natural seedlings attaining a height of about 3–5 in. during the first season and 9 in. to 1 ft. in three years.

Silvicultural characters. The tree is a moderate light-demander. It coppices well and produces root-suckers freely, especially when trees are felled or when the superficial roots are exposed and wounded. The branches are somewhat liable to be broken by snow.

Natural reproduction. Under natural conditions the seed germinates about April. Seedlings spring up in abundance on newly exposed ground, and particularly on deep loose rubble; natural reproduction may often be found in quantity on landslips and places recently eroded by snow.

3. **Prunus nepalensis,** Hook. f. Vern. *Arupatti*, Nep.

A large tree of the central and eastern Himalaya at 6,000–10,000 ft., Khasi hills, Upper Burma in evergreen forest in the Ruby Mines district at 6,000 ft. Bark greyish black, thin, smooth; branches verticillate. Mr. F. B. Manson [1] says the seeds, which are distributed by birds, germinate very easily in the end of February and the beginning of March, even when hoar-frost is frequent, and that the seedlings seem to thrive almost as well under cover as in the open, and are very common and useful for restocking blanks. He adds that the tree has an extensive range, but in the Darjeeling hills it thrives best between 6,000 and 6,500 ft.; here it grows quickly, and sound trees of 8 to 10 ft. in girth with fine straight boles are met with. In this locality the new leaves appear in March, the flowers in May, and the fruit ripens in October–November.[2]

2. PYRUS, Linn.

Pyrus Pashia, Ham. Syn. *P. variolosa*, Wall. Vern. *Patangi*, Hazara; *Káint, mehál*, W. Him.

A moderate-sized deciduous tree of the Himalaya at 2,000–8,000 ft., Khasi hills and hills of Upper Burma. In the outer Himalaya it is very common on open sunny slopes, often with *Quercus incana*, *Rhododendron arboreum*, *Berberis aristata*, *B. Lycium*, and *Pieris ovalifolia*, and lower down with *Pinus longifolia*, while at the base of the hills it is associated with low-level species, for example at Dehra Dun. It has spreading superficial roots and reproduces with great freedom from root-suckers, especially on hill-sides where the roots have become exposed; in this respect it is useful in preventing landslips. It can be grown from cuttings, and forms a useful stock for the apple. The leaves fall in November or early December, turning nearly black before falling, and the trees are leafless until the following March or April, when the new leaves appear; at low elevations they may appear as early as February. The white flowers appear with the new leaves, but occasionally trees may be seen flowering out of season, as late as July. The fruit is a globose five-celled pome 0·6–1·2 in. in diameter, greenish brown, covered with raised light grey dots, resembling a miniature apple, with brownish black shining seeds like small apple seeds. The fruits become full-sized by about July or August, but remain hard, with a firm whitish very astringent flesh until November–December, when the flesh begins to rot and turn black and sweetish:

[1] Working Plan for the Darjeeling Forests, 1893.

[2] Gamble, Darjeeling List.

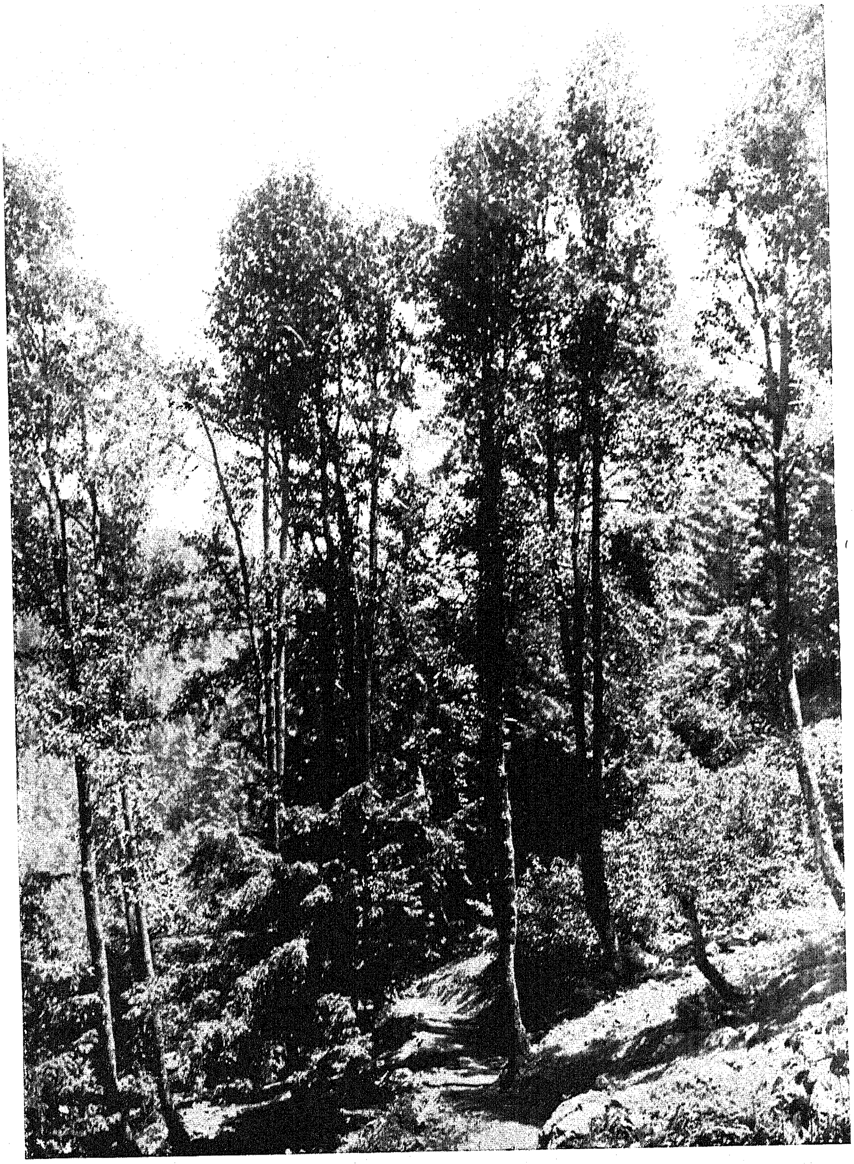

Fig. 185. *Prunus Padus* growing gregariously, with an underwood of *Taxus baccata*, Hazara.

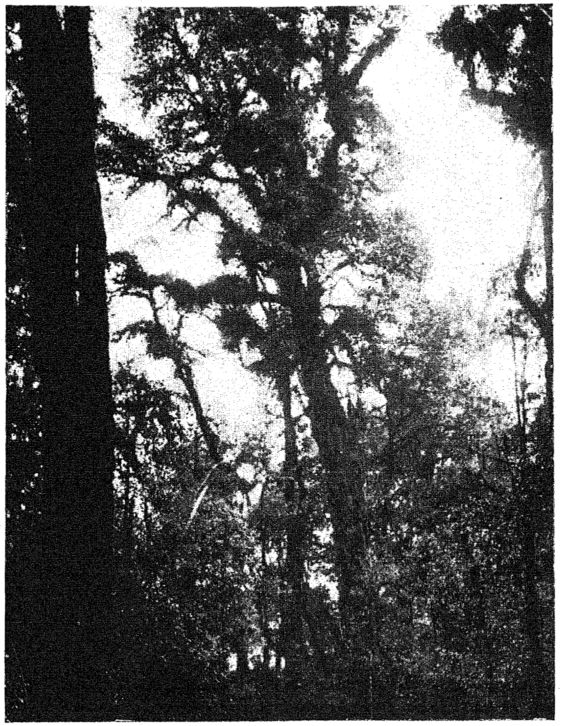

FIG. 186. *Bucklandia populnea*, mature tree, girth 22 ft. 6 in., height 140 ft., bole 85 ft., Darjeeling hills.

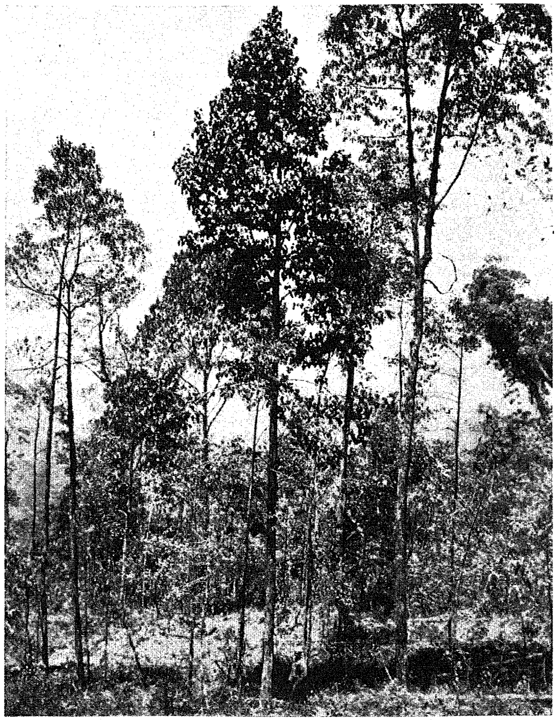

FIG. 187. *Bucklandia populnea*, pole (in centre with man at base) grown in sufficiently close crop to produce a clean bole, Darjeeling hills.

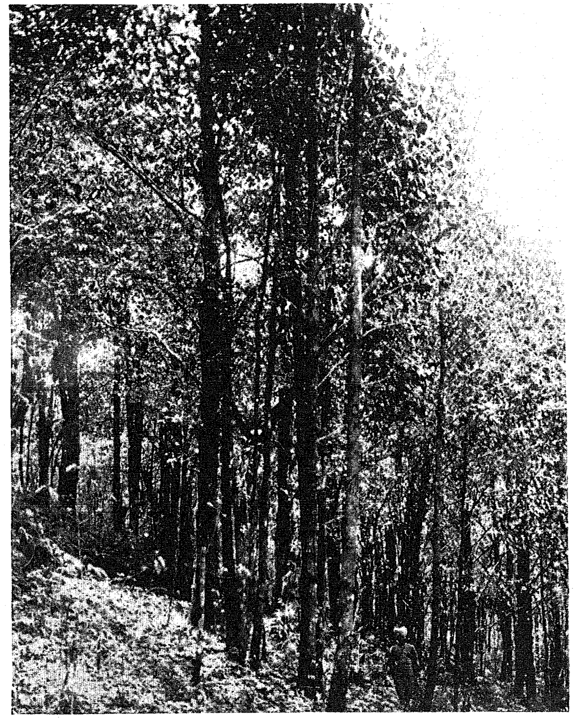

FIG. 188. *Bucklandia populnea* plantation between 20 and 30 years old.

they are conspicuous on the leafless trees during the earlier part of the winter. The fruits are left untouched by birds, though sometimes eaten by monkeys, until they become over-ripe, in which condition they are eagerly devoured by birds, including crows, which visit the leafless trees in winter, testing each fruit and eating those which have become soft and leaving those which have not yet reached this condition ; in this way the seeds are scattered.

Gamble notes that the leaves are attacked by the fungus *Gymnosporangium Cunninghamianum*, Barcl., whose alternate generation is on the Himalayan cypress, and that another species is also found on it, *G. clavariaeforme*, Jacq., whose alternate generation is probably on the juniper.

The growth is moderate. Gamble's specimens showed 8 rings per inch of radius, or a mean annual girth increment of 0·78 in. A cross-section 2 ft. 10 in. in girth in the silvicultural museum at Dehra Dun had 31 rings, giving a mean annual girth increment of 1·1 in.

ORDER XXV. HAMAMELIDACEAE

Genera 1. Bucklandia, R. Br.; 2. Parrotia, C. A. Meyer.

1. BUCKLANDIA, R. Br.

Bucklandia populnea, R. Br. Vern. *Pipli*, E. Him.

A tall handsome evergreen tree with cordate shining coriaceous leaves and thick fleshy stipules. Bark of poles blackish and slightly rough, that of old trees reddish brown and deeply furrowed. The bole is long but seldom entirely free from side branches, and the crown is dense and spreading ; poles grown in the open are pyramidal in shape, and often have several leading shoots. The tree reaches very large dimensions, attaining a height up to 140 to 150 ft. Mr. H. S. Gibson records a tree 22 ft. 6 in. in girth (see Fig. 186) ; the largest apparently sound stem measured by him was 17 ft. in girth.

This is one of the most valuable trees of the Darjeeling hills, with a reddish brown durable wood used for planking, flooring, door and window frames, and many other purposes. It is one of the best trees for afforestation and for the protection of hill slopes liable to landslips ; it is also an excellent soil-improver. It was at one time so extensively cut out in the Darjeeling forests that there are now very few large trees left, and the timber seldom comes on to the market ; it is, however, being extensively planted.

Distribution and habitat. The eastern Himalaya, Khasi hills, Manipur, and the hills of Martaban. In the Darjeeling hills it is found between 3,000 and 8,000 ft., but thrives best between 4,000 and 6,500 ft. The climate here is moist, the normal rainfall being about 120 to 160 in. The tree is found on various aspects ; a northerly aspect suits it best, no doubt owing to favourable conditions of soil moisture, but plantations on southerly dry slopes have succeeded well, showing that it is adaptable. It prefers a thoroughly moist sandy loam, though it does well on clayey soils, and is not exacting : it grows better in depressions than on ridges. The tree grows in mixture with other species of the Darjeeling hills, but has a great tendency to regenerate on newly exposed ground on landslips and similar places, where it often forms

pure groups; on such places it is frequently associated with *Alnus nepalensis*, which also regenerates freely on newly exposed ground. It occurs sometimes on precipitous ground.

FLOWERING AND FRUITING. The tree produces flowers and fruits at various seasons, and one tree in flower and another in fruit may be found side by side. The fruit is a small globose capsule, in which the lower seeds are winged and fertile and the upper ones are sterile. The seeds (Fig. 189, *a*) are 0·2–0·3 in. long, compressed, angular, reddish brown, smooth, moderately hard, light, about 7,000 weighing 1 oz. The small light winged seeds are capable of being blown to a considerable distance by the wind. Good seed-years are of frequent occurrence. Although seed is obtainable at almost any time of year, Mr. J. R. P. Gent has observed that seed collected in March gives the best results, possibly because the climatic conditions in the following months are most favourable for germination and early development; these conditions are sufficient warmth and probable showers of rain in May. Great care is necessary in collecting the seed. If collected a day or two before it is actually ripe it will not germinate, while if collection be delayed too long the seed will have escaped from the capsules. The fruits should therefore be collected when they are just commencing to open and spread in the sun to open them, the seed then being shaken out and sown at once.

GERMINATION (Fig. 189, *b–i*). Epigeous. The whitish radicle emerges from one end of the seed, the hypocotyl elongates by arching and soon straightens, carrying the cotyledons above ground. The testa is almost always carried up over the cotyledons, and frequently adheres to the end of one of them after they expand, eventually falling to the ground.

THE SEEDLING (Fig. 189).

Roots: primary root moderately long, at first thin and delicate, afterwards wiry, flexuose: lateral roots numerous, long, fibrous. *Hypocotyl* distinct from root, 0·5–0·8 in. long, terete or slightly compressed, white or pink turning green, minutely pubescent. *Cotyledons*: petiole about 0·05 in. long: lamina 0·3–0·35 in. by 0·2 in., foliaceous, somewhat fleshy, elliptical or ovate, apex rounded, entire, glabrous. *Stem* erect, terete or slightly compressed, pubescent, appearing jointed owing to the ring-like scars left by the stipules after falling. *Leaves* simple, alternate. Stipules 0·2 by 0·1 in. in young seedlings, up to 0·8 by 0·4 in. in second season, somewhat unequally elliptical, pubescent, enclosing the terminal bud, deciduous. Petiole 0·2–2 in., pubescent. Lamina 1–2·5 in. by 0·9–2 in., cordate, acuminate, entire, glabrous above, slightly pubescent beneath, venation arcuate with five prominent veins from the base. The leaves increase considerably in size, to about 4–5 in. long and broad in the second season.

The growth of the seedling for the first few years is somewhat slow. It reaches a height of only a few inches by the end of the first season, adding a few inches more by the end of the second season; plants raised at Dehra Dun were 4–10 in. high at the end of the second season. The seedlings are capable of standing a fair amount of shade, but once established they develop much better if full light is admitted; shade tests at Dehra Dun showed that they are killed by very dense shade. In heavy weed-growth the young plants become suppressed, but if they surmount the weeds their strong leaders penetrate through almost anything. At Dehra Dun they were found to damp

FIG. 189. *Bucklandia populnea.* Seedling.

a, seed × $\frac{3}{2}$; *b–i*, germination stages (*b–h* × $\frac{3}{2}$, *i* × $\frac{1}{1}$); *j–l*, development of seedling during first season × $\frac{1}{2}$; *m*, seedling early in second season × $\frac{1}{2}$.

off if given too much water. The seedling is sensitive to frost, but in its natural home it is usually out of danger after it reaches a height of 3 or 4 ft. At Dehra Dun seedlings in the open were killed in large numbers during the winter. The young plant is not usually considered very sensitive to drought in the Darjeeling hills, but at Dehra Dun seedlings in the open died off in large numbers during the hot weather even when watered, whereas those kept under slight shade survived.

Silvicultural characters. The tree is a shade-bearer, and also gives heavy shade; it develops best, however, with abundant overhead light, though it requires to be grown in a close crop in order to counteract its tendency to form numerous side branches. Fig. 187 shows a pole grown in a crop sufficiently dense to produce a clean bole. It does not coppice except when young, and it does not produce root-suckers. It is sensitive to frost in youth, but later it is immune in its natural home. In dry situations it is liable to suffer from prolonged drought, but in the Darjeeling hills it is seldom severely tried in this respect. It is very sensitive to fire, and although pole crops are capable of surviving light ground fires they are killed by severe fires. The young plants are sensitive to grazing; they are readily eaten by cattle and by deer, and plantations accordingly require to be fenced, particularly against the latter.

Natural reproduction. As already mentioned, the small light winged seeds are carried by wind to a considerable distance from the tree, and seedlings are therefore often found a long way from any seed-bearer. The tendency to regenerate in masses on newly exposed ground on landslips and similar places has already been noted: this is a characteristic of many species with small light seeds, and is due largely to the fact that such seeds are unable to reach the ground when it is covered with a mass of undergrowth or a low thick herbaceous growth of weeds and grass, while the small seedling is unable to effect contact with the mineral soil except where the latter is exposed. Natural seedlings, however, are not confined to landslips, and are found in other places where there is no heavy soil-covering and where the shade is not too dense for their development, for instance along paths, on ridges, and sometimes in the forest itself where conditions are favourable.

Artificial reproduction. The tree has been extensively grown in plantations in the Darjeeling hills. Seed is sometimes sown broadcast on landslips, but otherwise transplanting from the nursery is the invariable rule. Pure plantations have been found to give better results than plantations where *Bucklandia* is mixed with *Michelia excelsa* and oaks. Experience has also shown the unsatisfactory results of wide spacing owing to the tendency of this species to form numerous side branches; a spacing of not more than 6 ft. by 6 ft. is now considered advisable.

The usual method adopted in the forest nurseries in the Darjeeling hills is to sow freshly collected seed in nursery beds of fine earth in March or April, the seed being lightly covered with earth. The seedlings are either pricked out 6 in. by 6 in. at the end of the first season and again transplanted 6 in. apart in lines 9 in. apart at the end of the second season, or left for two years in the seed-beds and transplanted into nursery lines 1 ft. apart in the third season. Beds containing seedlings up to two years old are protected by screens

FIG. 190. *Bucklandia populnea* plantation 5 years old, Surail, Darjeeling hills, 4,300 ft. elevation.

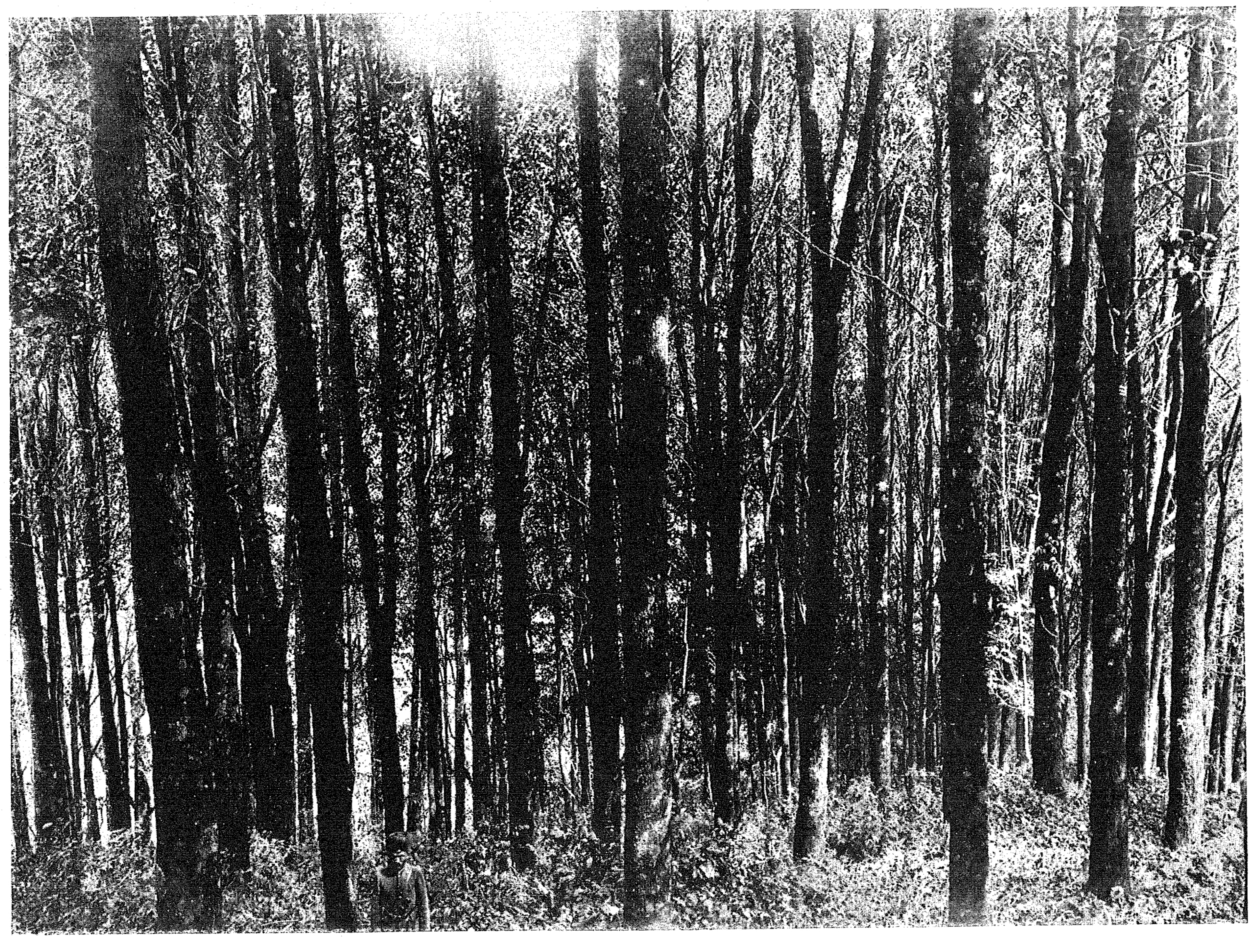

Fig. 191. *Bucklandia populnea*, interior of plantation 38 years old, below Rangirum, Darjeeling hills.

from heavy rain, from frost in the winter, and from a hot sun in the summer. The seedlings are usually kept in the nursery until four years old, by which time they are about 3 ft. high and are large enough to plant out into the forest; they can be transplanted when three years old, but they are usually somewhat small and the extra cost of cleaning makes it preferable to keep them a year longer in the nursery.

Transplanting is usually carried out in the rainy season from June till early August. A break in the rains is considered the best time, as plants pitted out in rainy weather are apt to become water-logged and to die owing to an accumulation of water in the pit. Nursery plants often have too much foliage, and this should be reduced at the time of planting to prevent excessive transpiration. Winter planting is possible, but the risk of frost damage makes rains planting preferable. In places subject to severe frost it is customary to protect the plants during the first year after transplanting, usually by means of a leafy branch stuck in the ground beside the plant and broken over it. The plantations require to be fenced against deer.

In the Mongpoo plantations of the Cinchona Department a different method is adopted. The seed is sown in March and April in well-manured seed-beds under the shelter of double bamboo mats. When about 3 in. high the seedlings are pricked out about 3 in. apart: they are kept well weeded and watered, and by the end of June in the second year are about 8 or 9 in. high. The shelter of bamboo mats is then gradually removed and the seedlings are transplanted with balls of earth, the planting holes being dug to a depth of 18 in. at least a fortnight in advance. The plants are tended carefully for the first year or so after they are put out, and when there is danger of drought the ground around their roots is covered with grass. When the ground becomes hard it is forked up all round the plants. Under this treatment the growth is fast, the plants attaining a height of 20 ft. in seven or eight years on good soil.

Fig. 190 shows a young plantation, and Figs. 188 and 191 show older plantations.

Silvicultural treatment. The best treatment for *Bucklandia* is to grow it in dense pure crops with sufficient side shade to prevent the formation of side branches but with abundant overhead light to promote height-growth. The tending of natural plants or crops as well as of plantations requires to be carried out with this object in view.

Rate of growth. Young plants ordinarily reach a height of 3 ft. in five years and 8 to 15 ft. in ten years. At fifteen years the height is about 15 to 25 ft., and at twenty years about 30 to 40 ft., with a girth of $1\frac{1}{2}$ to 2 ft. According to Gamble the radial growth is 6 to 7 rings per inch of radius, representing a mean annual girth increment of 0·9 to 1 in., which is fairly fast.

A plantation below Rangirum in the Darjeeling hills, shown in Fig. 191, was measured in 1917 with the following results:

Age. years.	No. of stems per acre.	Mean girth. in.	Mean height. ft.	Solid volume per acre. cub. ft.
38	220	36·2	79	4,517 (timber 2,889 cub. ft.)

A thinning carried out that year gave a total of 1,632 cub. ft., of which timber amounted to 878 cub. ft.

2. PARROTIA, C. A. Meyer.

Parrotia Jacquemontiana, Dcne. Himalayan witch-hazel. Vern. *Páser, kilár, shtar,* Punjab.

A large gregarious deciduous shrub or small tree, strongly resembling a hazel, occurring between 3,000 and 8,500 ft. in the Himalaya from the Jumna westward. It is used chiefly for wicker-work for the walls of houses and for rope-bridges, the twigs being flexible and very tough : it is also used for walking-sticks and other purposes. Silviculturally it is of importance owing to the abundance with which it springs up as an underwood in certain localities. It coppices very vigorously, stands a certain amount of shade, and forms dense masses which impede the reproduction of deodar, blue pine, and other trees. It is a good soil-improver, and if it can be kept down sufficiently to allow young deodar and pine to penetrate its cover they grow well : the only means of ensuring this seems to be to cut back the *Parrotia* repeatedly, a costly operation owing to its vigorous power of coppicing.

ORDER XXVI. RHIZOPHORACEAE

This order comprises for the most part a number of littoral species collectively known as mangroves, which, together with certain species belonging to other natural orders, make up the curious littoral forest formation known as mangrove swamp. Of non-littoral species the most important is *Carallia lucida,* Roxb.

Mangrove swamp. Mangrove forest is found in littoral regions throughout the tropics, not along sandy beaches or rocky shores which are exposed to the full force of the wind and the waves, but in the estuaries of rivers, in creeks and lagoons, and on low islands where the force of these agencies is not so strong. In such places the mangrove belt occupies a strip of low-lying muddy ground, subject to inundation by ordinary tides, the strip varying in width from less than a hundred yards to several miles.

Distribution and species. In a classification of the mangrove formations of the world two broad but well-defined areas are distinguishable—an eastern area embracing East Africa, Asia, and the Polynesian Islands down to Australia, and a western area comprising the coasts of America and West Africa. The species in the respective areas are distinct, but the eastern area is far richer in species than the western. The most extensive and highly developed mangrove forests are found in the Malayan region, and particularly in the island of Borneo, where the configuration of the country favours the formation of mangrove swamps over large areas in the coastal regions.[1]

In the Indo-Burman region the mangrove forests are distributed to a greater or less extent in suitable localities throughout the coastal regions, from the delta of the Indus in Sind southwards along the west coast of the Peninsula down to Travancore, from the Sundarbans southwards along the east coast of the Peninsula and down the coast of Chittagong, Arakan, and Burma ; also along the coast of the Andamans and adjacent islands. The mangrove forests of Arakan are estimated to cover 948 square miles, while

[1] Distribution and Utilization of the Mangrove Swamps of Malaya, F. W. Foxworthy, 1909 (Ann. Jard. Bot. Buitenzorg, 2e sér., Suppl. III).

there are further large stretches of mangrove both north and south of Mergui along the coast and round the islands.

The natural orders and the principal species which make up the mangrove formations of the Indo-Burman region, and the localities in which they are known to occur, are given in the following tentative table :

Distribution of mangrove swamp species in the Indo-Burman region.

Natural order.	Specis.	Sind (Indus delta).	Indian Peninsula, west coast.	Indian Peninsula, east coast.	Sundarbans.	Chittagong.	Burma.	Andamans.
Rhizophoraceae	*Rhizophora mucronata*, Lam.	×	×	×	×	×	×	×
	R. conjugata, Linn.	×	×	?	?	×	×	×
	Ceriops Candolleana, Arn.	×	×	?	×	..	..	×
	C. Roxburghiana, Arn.	×	×	?	×	×	×	..
	Kandelia Rheedii, W. and A.	..	×	×	×	×	×	×
	Bruguiera gymnorhiza, Lam.	×	×	×	×	×	×	×
	B. eriopetala, W. and A.	..	×[1]	..	..	..	..	..
	B. caryophylloides, Bl.	..	×[2]	..	..	..	×[3]	..
	B. parviflora, W. and A.	..	..	..	×	..	×[3]	×
Meliaceae	*Carapa obovata*, Bl.	..	×	?	×	×	×	×
	C. moluccensis, Lam.	..	..	..	×	..	..	×
Leguminosae	*Cynometra ramiflora*, Linn.	..	×	×	×	×	×	×
Combretaceae	*Lumnitzera racemosa*, Willd.	..	×	?	×	×	×	×
	L. coccinea, W. and A.	..	..	..	..	..	×[4]	×[5]
Lythraceae	*Sonneratia acida*, Linn. f.	×	×	×	×	×	×	×
	S. apetala, Ham.	..	×	?	×	×	×	..
	S. alba, Smith	..	×	..	..	..	×[4]	×
	S. Griffithii, Kurz	..	..	..	..	..	×	..
Rubiaceae	*Scyphiphora hydrophyllacea*, Gaertn.	..	..	×	..	..	..	×
Myrsinaceae	*Aegiceras majus*, Gaertn.	×	×	×	×	×	×	×
Acanthaceae	*Acanthus ilicifolius*, Linn.	..	×	?	×	×	×	..
Verbenaceae	*Avicennia officinalis*, Linn.	..	×	×	×	×	×	×
Euphorbiaceae	*Excaecaria Agallocha*, Linn.	..	×	×	×	×	×	×
Palmeae	*Nipa fruticans*, Wurmb.	..	..	..	×	×	×	×
	Phoenix paludosa, Roxb.	..	..	..	×	×	×	×

[1] Malabar and Travancore. [2] Travancore. [3] Tenasserim. [4] Mergui. [5] Nicobars.

Although the species mentioned in this table occur in the mangrove swamps, some of them are by no means confined to them, and may extend to the drier ground farther inland.

Characteristics of mangrove swamps. Mangrove swamps are formed on the silt which is washed down by rivers and creeks, and which, subject to occasional erosion, gradually spreads seawards, the mangrove spreading with it and helping, by means of its dense growth and mass of roots, to hold up the silt and form new land. As the silt accumulates the ground gradually rises and becomes drier, and an entirely new formation replaces the mangrove; this formation occurs on land which is inundated only by spring tides, and is commonly known as tidal forest. The most important Indian species of the tidal forest is the *sundri* (*Heritiera Fomes*). Although some of the species of the mangrove swamp extend into this forest many new species appear. The mangrove formation extends up rivers sometimes for miles, and is usually intersected by numerous creeks, which are often dry at low tide but can be

ascended by boats at high tide. The ground is a soft mud which is often knee-deep, but can be traversed on foot, with some difficulty and discomfort, at low tide. On the seaward side there is usually a stretch of shallow water into which the mangrove is spreading, and approach by boat from that side is often difficult or impossible; the mangrove swamp can, however, be penetrated by boat and often by launch, along the creeks.

Root-system. The root-system of the mangroves is highly specialized. In the case of *Rhizophora* the lower part of the stem dies early, and the stem is supported by numerous stilt-like roots which raise it above the mud, while aerial roots are sent down from the stem and branches and anchor themselves in the ground. These stilt-roots are covered by water at high tide and exposed at low tide. *Rhizophora* is usually characteristic of the outer edge of the mangrove swamp, and the mass of stilt-roots is a conspicuous sight on approaching the shore. These peculiar stilt-roots are not conspicuously developed in other species of the mangrove formation except in *Acanthus ilicifolius*, a thistle-like herbaceous or shrubby plant with prickly leaves, which sometimes forms a dense undergrowth. In other species the roots are superficial, twisting about on the surface of the mud, sometimes ribbon-shaped as in *Carapa obovata*, sometimes bending out of the mud in the form of knees (i. e. knee-rooted), as in *Bruguiera*, *Kandelia*, and *Lumnitzera*. Some species produce pneumatophores which rise out of the mud from the superficial roots and resemble inverted tent-pegs. The ribbon-roots, knee-roots, and vertical pneumatophores, some mere knobs or finger-like outgrowths and others, as in *Sonneratia apetala* and *Avicennia officinalis*, of considerable size, are all adaptations for supplying the roots with oxygen, and are covered with lenticels or exhibit other devices for breathing purposes, such as the shedding of cortex.

Leaf-structure. The habitat of the mangroves, namely swampy ground impregnated with salt, is a physiologically dry one, and the leaves of the trees therefore possess a marked xerophilous structure, 'with a thick cuticle, large mucilage-cells, protected stomata, and especially a large-celled thin-walled, aqueous tissue, the dimensions of which increase with the age of the leaf and with the corresponding rise in the amount of salt contained. Old leaves serve essentially as water-reservoirs for the younger leaves' (Schimper).

Germination. One of the most interesting characteristics of the Rhizophoraceae is that they exhibit vivipary. The fruit is indehiscent, and there is no resting stage for the embryo as in the case of normal seeds. As soon as the fruit is fully developed the embryo commences to grow inside it; the radicle soon pierces its apex, and the hypocotyl elongates and protrudes, hanging vertically from the fruit. After it has reached a length varying from a few inches in some species to $1\frac{1}{2}$–2 ft. or more in the case of *Rhizophora mucronata*, the embryo plant falls, leaving the cotyledons inside the fruit, which remains on the tree. The lower part of the hypocotyl is thicker than the upper part, and in some cases the lower extremity (radicle) comes to a sharp point; when the embryo falls into the mud, therefore, it becomes firmly planted in a more or less vertical position. Within a short time of falling the young seedling produces rootlets from its lower extremity, thus further establishing itself, and before long the first pair of foliage leaves are produced at its apex. The embryos are buoyant, and if they do not obtain an immediate footing under

the parent tree, or are uprooted, they are carried by water and find a resting-place in the mud, eventually establishing themselves in an upright position through the positively geotropic nature of the lower extremity and the negatively geotrophic nature of the upper extremity (shoot).

It will thus be seen that the term sowing or dibbling of mangrove seed is strictly speaking incorrect; it is the embryo or young seedling which is planted in the ground.

In the other species of the mangrove formation vivipary is also exhibited by *Aegiceras majus* and *Avicennia officinalis*, and although it does not occur in other species, the embryos of some, particularly those of *Acanthus ilicifolius*, are always further developed than is usual in inland plants.

Local occurrence of species. The requirements of the various species of the mangrove swamp differ to some extent, particularly as regards water, and their local distribution is influenced accordingly. The species of *Rhizophora* grow typically on the outer and seaward fringe of the swamp, where the water is most salty and exposure to wind and wave is greatest. *R. mucronata* can apparently live in pure salt water, for Schimper notes that he has seen it thriving on the rocky ground of the coral islands of the Java Sea, where there is no fresh water.[1] *Ceriops* spp. grow well out in the swamp. *Bruguiera gymnorhiza* and *B. parviflora* require a greater admixture of fresh water, and grow farther inland behind the *Rhizophora*, the first named, the largest of the mangroves, overtopping the surrounding vegetation. *Sonneratia* spp. and *Avicennia officinalis* not only grow in deep mud in the mangrove swamp, but also extend some distance inland into the tidal forest, and are found in the upper stretches of the tidal streams. *Carapa* spp. occur mainly in the drier parts of the swamp, often near or just beyond high-water mark, and extend into the tidal forest in areas remote from the mangrove swamp. *Avicennia officinalis* may occur near the outer edge of the swamp or at some distance up tidal streams on wet ground: it sometimes comes up in abundance on cleared areas. *Acanthus ilicifolius* sometimes forms a rather dense prickly undergrowth, growing near the sea. The palm *Nipa fruticans* is at times very abundant, not only in the mangrove swamp but also in the drier tidal forest beyond high tide, forming fringes along the banks of creeks.

Interference with the free flow of tidal water and of fresh water from the landward side may alter the character of or destroy the normal vegetation of the mangrove swamp. Thus at Port Blair in the Andamans attempted reclamation by means of embankments has rendered large areas unfit for the growth of mangroves, and marshy blanks have resulted.

Method of working mangrove forest. The working of mangrove forest is carried out under different methods. The coppicing and pollarding capacity of the different species have not been studied in detail. In unregulated fellings rough pollarding is often carried out. Working plans for mangrove areas in the Madras Presidency prescribe coppice fellings under a rotation of five years in one case and ten years in another. Larger trees which have been pollarded are said to have thrown out vigorous pollard-shoots. In the Andamans a considerable area has been clear-felled and replanted. In the Federated Malay States the selection system is in operation, the felling cycle being twenty

[1] Plant Geography, p. 396.

years, and the minimum felling limit being a girth of 1 ft. at 4½ ft. from ground-level. The system is said to be difficult to control, and when, as sometimes happens, the crop consists mainly of stems 1 ft. in girth and over, clearings may result, and artificial reproduction has to be resorted to.[1] The retention of seed-bearers in such places should help to regenerate the blanks naturally.

ARTIFICIAL REPRODUCTION. Artificial reproduction is a simple matter, the embryos being collected off the ground after falling and stuck vertically in the mud. In the Andamans mangrove plantations were commenced in 1897, the species employed being *Rhizophora mucronata*, *R. conjugata*, *Bruguiera gymnorhiza*, *B. parviflora*, *Kandelia Rheedii*, and *Ceriops Candolleana*. These plantations were extended until 1908, when the total area amounted to 685 acres, the cost of creation being Rs. 5,368 or slightly under Rs. 8 per acre. The original spacing is said to have been 3 ft. by 3 ft., which proved to be excessively close, and some years later alternate rows were cut out, as well as alternate saplings in each row, leaving a spacing of 6 ft. by 6 ft. These plantations have suffered much from the erection of bunds already referred to, whereby the flow of fresh and tidal water was interfered with.

In Burma in 1908 five acres in the Zapathwe fuel reserve in the Hanthawaddy district were cleared of all undergrowth and species of little value and planted 4 ft. by 4 ft. at the end of October with *Rhizophora mucronata* (2 acres), *R. conjugata* (1 acre), and *Kandelia Rheedii* (2 acres). The overhead clearance caused early drying of the mud, while hog-deer ate off the main shoots, with the result that only about 30 per cent. of the seedlings survived until the following May, and these were in poor condition. Similar experiments with *Rhizophora mucronata* and *R. conjugata* in the Mingalun fuel reserve in the same district gave better results, about 30 per cent. of the former species and 40 per cent. of the latter being in good condition, with a height of about 2½ ft., by the following May. In the Federated Malay States the embryos are usually dibbled in 4 ft. by 4 ft. or 6 ft. by 4 ft., and the percentage of survivals is high, almost the only danger being from crabs, which eat through the stem at its base.

RATE OF GROWTH AND OUT-TURN. The rate of growth of mangroves is said to be slow, but actual statistics are not available except in the case of the Andamans plantations, where *Rhizophora mucronata* and *Bruguiera gymnorhiza* attained a height of 30–35 ft. and a girth of 9–12 in. in fifteen years. Sample plots in Arakan gave an average yield per acre of 3 tons of bark and 25 tons of wood in clear-felled coupes.

Genera 1. RHIZOPHORA, Linn.; 2. CERIOPS, Arn.; 3. KANDELIA, W. and A.; 4. BRUGUIERA, Lam.; 5. CARALLIA, Roxb.

1. RHIZOPHORA, Linn.

Species 1. *R. mucronata*, Lam.; 2. *R. conjugata*, Linn.

1. **Rhizophora mucronata,** Lam. Vern. *Bhara*, Beng.; *Kandal*, Mar.; *Kamo*, Sind; *Uppu poma*, Tel.; *Pyu*, Burm.

A small to moderate-sized evergreen tree with elliptical mucronate leaves 4–7 in. long, the young branches thick and prominently marked with the scars of fallen leaves and stipules. Bark fairly smooth, brown. This tree produces

[1] The Mangrove Forests of the West Coast, F.M.S., J. P. Mead, 1912.

characteristic stilt-roots, the lower portion of the stem dying early and the tree remaining propped up on numerous roots which are submerged at high tide and stand out of the mud at low tide. Aerial roots are also produced from the branches, these fixing themselves in the mud. This tree is the one most commonly found on the outer fringes of the mangrove swamp where the water is decidedly salty and the action of the tides and waves is most strongly felt: its peculiar root-system therefore is of special advantage in forming an anchorage to withstand this action.

The conspicuous white flowers appear in the hot season and rainy season, and the fruits ripen in the rainy season. The fruit (Fig. 192, *a*) is 1·5–2 in. long, conical-ovoid, pendulous, coriaceous, rough, dark brown. The hypocotyl (Fig. 192, *b–d*), which emerges through the apex of the fruit, is sharp pointed and rough with lenticels. Before dropping it attains a considerable length, ordinarily up to 1½–2 ft., but sometimes longer, and the seedling is thus able to establish itself in water of some little depth, the sharp point of the hypocotyl penetrating the mud and the young plant being kept upright while the roots are rapidly developed and the first pair of foliage leaves appear at the apex of the shoot. Seedlings which have established themselves in this way may often be found in quantity in the mud and shallow water round the parent trees. The tree commences to produce fruits at an early age.

The sapwood is light red and the heartwood dark red, hard, but splits in seasoning. It is a good fuel. The bark is used for tanning.

2. **Rhizophora conjugata,** Linn. Vern. *Pyu-ma*, Burm.

A tree somewhat smaller than, but with habits similar to those of the last species, with which it is commonly associated. The leaves are narrower and darker than in *R. mucronata*; it can be most easily distinguished by the calyx-lobes, which are pale yellow within. The fruit is about 1 in. long; the hypocotyl is smaller than in *R. mucronata*, up to about 1 ft. long.

2. CERIOPS, Arnott.

Species 1. *C. Candolleana*, Arn.; 2. *C. Roxburghiana*, Arn.

1. **Ceriops Candolleana,** Arn. Vern. *Goran*, Beng.; *Chauri*, Sind.

2. **Ceriops Roxburghiana,** Arn. Vern. *Goran*, Beng.; *Guttia*, Chittagong; *Kabaing*, Burm.

Small evergreen trees resembling each other in appearance and habit, and distinguished mainly by the inflorescence, which is more compact in the latter than in the former. The bark of both species contains a great deal of red colouring matter. The stem is not supported by stilt-roots as in *Rhizophora*, but aerial roots are sent down from the branches, and small or inconspicuous pneumatophores are produced. The fruit, which is about 1 in. long, ripens in August–September, and the hypocotyl when it falls is 4–6 in. long by 0·25–0·35 in. in diameter, longitudinally grooved and ribbed, tapering upwards: about 120–150 of the embryos weigh 1 lb. Fig. 192, *e–g*, shows germination and the development of the young seedling.

Brandis gives the respective distribution of the two species as follows:

C. Candolleana. Tidal forests of Sind, the Indian Peninsula, Bengal, and the Andamans. Sea-coast of tropical Asia, Africa, and Australia.

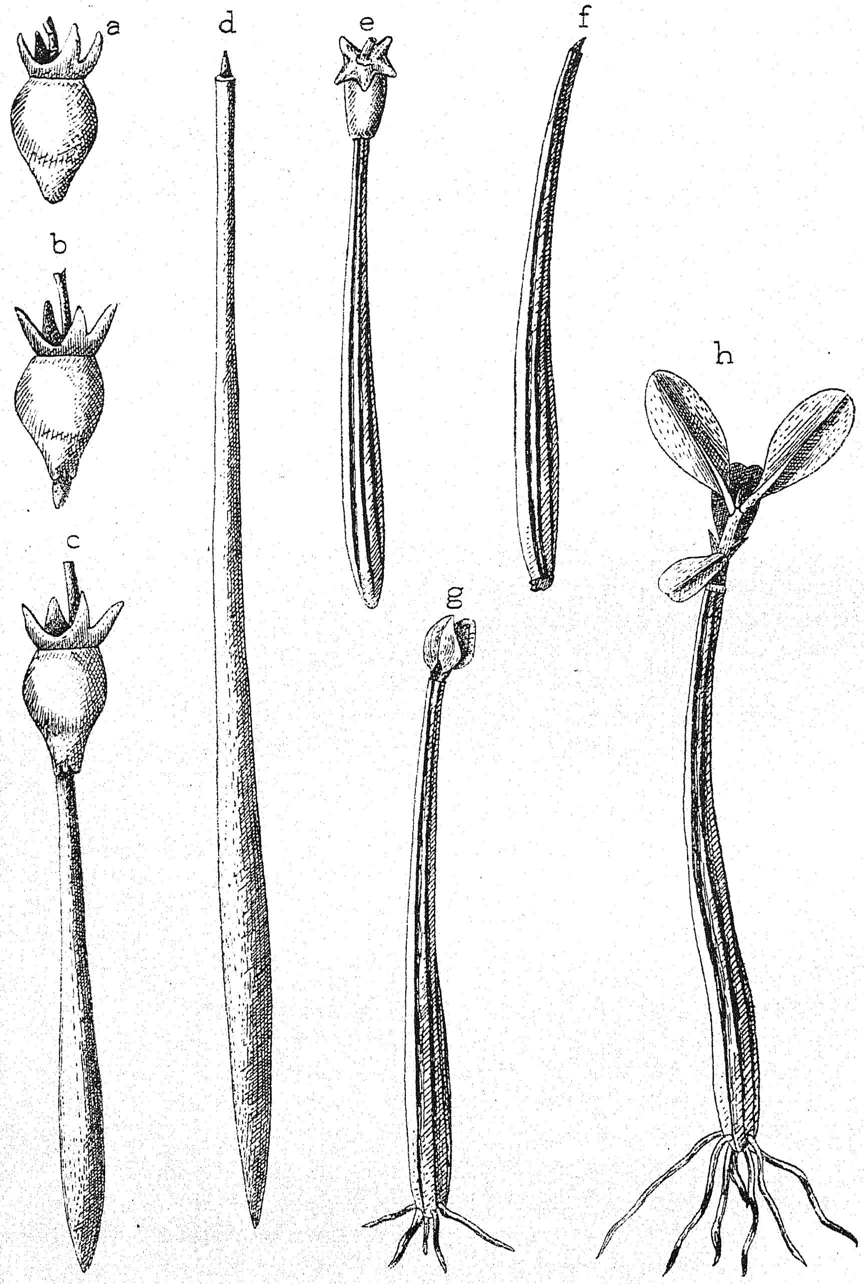

FIG. 192. Rhizophoraceae. Germination.

Rhizophora mucronata × $\frac{1}{3}$; *a*, fruit; *b*, fruit with radicle protruding; *c*, fruit with embryo (hypocotyl) half grown; *d*, embryo after falling from fruit.

Ceriops Candolleana × $\frac{1}{2}$; *e*, fruit with protruding hypocotyl fully developed; *f*, embryo detached from fruit; *g*, *h*. development of young seedling.

C. Roxburghiana. Sundarbans, coast of Burma, Malay Peninsula and Archipelago.

Both are indiscriminately known in the Sundarbans as *goran*, and are in great demand for fuel and house-posts. The *goran* is often gregarious, forming nearly pure forests in many places; it is also found in mixture with various other species. In Chittagong, *Ceriops* is worked as coppice on a rotation of eight years for the production of small fuel and of bark, the latter being sold to fishermen for tanning their nets. In the Malay region the bark is considered superior to that of any other mangrove for cutch making: it is also used for dyeing a red colour.

3. KANDELIA, Wight and Arn.

Kandelia Rheedii, W. and A. Vern. *Goria*, Beng.; *Madama*, Burm.

An evergreen shrub or small tree with spongy reddish brown flaky bark, elliptical oblong leaves 3–5 in. long, and white flowers. Fruits ovoid, 0·5–1 in. long, encircled by the calyx lobes; hypocotyl up to 15 in. long. This mangrove is not as a rule so common as most of the others; it occurs usually on the banks of tidal rivers some little distance inland, and not so much near the sea-face. The wood is soft, and is used only for fuel and charcoal.

4. BRUGUIERA, Lam.

Species 1. *B. gymnorhiza*, Lam.; 2. *B. eriopetala*, W. and A.; 3. *B. caryophylloides*, Bl.; 4. *B. parviflora*, W. and A.

1. **Bruguiera gymnorhiza,** Lam. Vern. *Kankra*, Beng.; *Kandal*, Mal.

This, the largest of the mangroves, is an evergreen tree attaining under favourable conditions a height of 80 ft., though in India a height of 30–40 ft. is more usual. In Malaya it is said to reach a height up to 100 ft. and a girth up to 5 or 6 ft. Bark rough, dark, with large corky lenticular patches. Flowers large, solitary, orange or red. Fruit 0·7–1 in. long, enclosed in the calyx tube and crowned by the 12–14 red calyx lobes. The hypocotyl usually grows to 6–12 in. in length before dropping, but may attain a length of 2 ft. The flowers and fruits are produced from June to October.

This tree is a common one in the mangrove forests of the Indian region, being associated with the two species of *Rhizophora* and occurring as a rule immediately behind them. Unlike these, however, it is not supported on stilt-roots, but produces knee-roots along the surface of the ground.

Bourdillon says it is very common on the backwaters about Quilon, forming with the two species of *Rhizophora* the majority of the mangroves seen there. Talbot says it is equally common with *Rhizophora* in the North Kanara mangrove formations, and Prain says it is the chief constituent of the mangrove jungles in the Cocos Islands.

The wood is reddish brown, very hard, used for beams, posts, planks, and firewood; it is said to be difficult to split. The bark is sometimes used for tanning.

2. **Bruguiera eriopetala,** W. and A.

A tree strongly resembling the last species, but smaller, with large, solitary, yellow flowers.

3. **Bruguiera caryophylloides,** Bl., including *B. malabarica*, Arn.

This is the smallest and probably the rarest species of the genus. The bark is thin, brown, the foliage light green, the leaves thinly coriaceous, and the flowers small, white, in 2- to 3-flowered cymes. The fruit is yellow, about 0·5 in. long, and the hypocotyl reaches a length of about 6–8 in. before falling. Flowering and fruiting take place in the rainy season.

4. **Bruguiera parviflora,** W. and A.

A small tree, widely distributed in the mangrove formations of the Eastern Hemisphere, and often very common, sometimes forming pure crops in the middle of the mangrove swamp. In some localities it attains a fair height, but it is always of small girth : in the Indian region it is a small tree or a mere shrub. The foliage is yellowish green, paler than in the previous species. The fruit is about 1 in. long, enclosed in the enlarged calyx : the flowers and fruits appear in the rainy season. The hypocotyl is furrowed, truncate, and reaches a length of only 4–5 in. before falling. The tree grows on drier ground than *Rhizophora*, chiefly away from the banks of streams, and often reproduces in great profusion.

5. CARALLIA, Roxb.

Carallia lucida, Roxb. Syn. *C. integerrima*, DC. Vern. *Shengali, panasi*, Mar. ; *Andi, andamuria*, Kan. ; *Karalli*, Tel. ; *Thekera-máhi*, Ass. ; *Maniawga*, Burm.

A moderate-sized to large handsome evergreen tree with a dense crown of shining opposite leathery elliptical leaves, and pronounced opposite branching. Bark moderately thick, the outer dead bark corky, furrowed, dark grey outside, pink when cut, the inner living cortex pale greenish yellow or pinkish when newly cut, turning orange brown on exposure. There are numerous small corky excrescences on comparatively small-sized twigs of the previous year's growth ; the new twigs are green. The numerous broad medullary rays are conspicuous as vertical streaks on the outer surface of the sapwood and on the inner surface of the cortex when the latter is stripped off. Sometimes the tree produces aerial roots, showing its relationship to the mangroves. The tree is at times mistaken for a *Garcinia*, and vice versa, but the pink corky bark is a distinctive feature, while the cut cortex of *Garcinia* spp. exudes a yellow gum-resin which is not present in that of *Carallia*. In Burma the tree reaches a height of 50–80 ft., with a girth of 6 or 7 ft. In the Indian Peninsula it is smaller.

The wood is hard and very ornamental if cut radially, the large medullary rays giving it the appearance of good oak ; the heartwood is red to chestnut-brown. The wood is suitable for panelling, furniture, picture-frames, and similar purposes.

Distribution and habitat. The tree is found in limited quantity in damp evergreen and swamp forests in the sub-Himalayan tract as far west as Dehra Dun ; it is very scarce in the west but commoner in the east. It occurs in Bengal, ascending to 4,000 ft. in Sikkim, Assam, Chittagong, Chota Nagpur along streams and ravines in Singhbhum (Haines), Orissa and the Circars, the Central Provinces in South Chanda along flowing streams in Ahiri and

Sironcha ranges (Haines), Western Ghats, Burma, chiefly in the moister parts of Pegu and Tenasserim : also in Ceylon, China, the Malay Peninsula and islands south to Australia. It is nowhere abundant, and is typical of moist localities, occurring in evergreen and semi-evergreen forests and along streams and moist shady ravines. In the Dehra Dun valley it is a constituent of true swamp forest, where it is associated with *Diospyros Embryopteris*, *Putranjiva Roxburghii*, *Eugenia Jambolana*, *Ficus glomerata*, *Pterospermum acerifolium*, *Cedrela Toona*, *Bischoffia javanica*, *Albizzia procera*, *Trewia nudiflora*, and *Calamus tenuis*. In the Bengal Duars it occurs in moist evergreen and semi-evergreen forest associated with *Dillenia indica*, *Michelia*, *Amoora*, *Dysoxylum*, *Meliosma*, *Turpinia*, *Eugenia* spp., *Elaeocarpus* spp., *Garcinia* spp., and several Lauraceae.

Bourdillon says it is common in all the evergreen forests of Travancore up to 4,000 ft. Talbot says it is found throughout the tropical rain forests of the Konkan and North Kanara. In Burma Kurz, in his Preliminary Report, mentions that it is frequent in Pegu and Tenasserim up to 4,000 ft. on metamorphic rocks, sandstones, and permeable laterite, in evergreen tropical and upper mixed forest ; it occurs also in the lower mixed forest where it verges on evergreen forest.

In its natural habitat the absolute maximum shade temperature varies from 95° to 110° F., the absolute minimum from 33° to 65° F., and the normal rainfall from 50 to 200 in. or more.

Flowering and fruiting. The small flowers with white petals, in trichotomous cymes, appear from December to March, and the fruits ripen about May–June. The fruit is globose, fleshy, 1-seeded, coriaceous. The seed is 0·2–0·3 in. in diameter, compressed, shaped like a crescent in which the horns are curled round to form an almost complete circle, reddish brown, somewhat rough, with a fairly thick hard testa and a copious white albumen : 840–980 seeds weigh 1 oz. (samples from Burma). The seed is perishable, and while on the ground is very liable to rot and to be attacked by insects. It is difficult to explain the scattered distribution of the tree otherwise than by the dissemination of the seeds by bird agency.

Germination. Epigeous. The testa splits round the edge, the radicle emerging through the opening so caused. The hypocotyl elongates by arching, raising the cotyledons above ground ; the ends of the cotyledons remain enclosed in the albumen of the seed for some little time before falling.

The seedling. Seedlings cultivated at Dehra Dun showed slow development during the first two seasons, reaching a height of 1½–2 in. by the end of the first season and 5–14 in. by the end of the second. In the earlier stages the young plants suffered much from the attacks of crickets. During the third and subsequent seasons growth was more vigorous, the height being 3 ft. 11 in. at the end of the third season, and 7 ft. 8 in., with a basal girth of 10½ in., at the end of the fifth season. The young plants were found to grow best under slight shade on ground kept well watered but loose. They proved sensitive to drought, but were not so frost-tender as might be expected from a tropical evergreen species.

Seedlings at Dehra Dun had two to three pairs of leaves by the end of the first season, the cotyledons persisting until the end of the season. Side

branches commenced to form in the second season, and from the third season onwards the branching was vigorous, with copious foliage. The following characters apply to the young plant:

Young stems bright green, somewhat flattened, with a longitudinal ridge up the centre of each flat side; nodes swollen. Leaves opposite, lanceolate, finely serrulate, coriaceous, glabrous, shining, darker above than below, up to 5·5 in. by 1·5 in. by the end of the second season; petiole 0·2–0·4 in. long. Young leaves very shiny, lighter green than the older ones, involute in the bud, with small acuminate interpetiolar stipules between them which quickly enlarge to 0·5–0·6 in. in length and fall, leaving well-marked brown scars extending across the shoot from base to base of the petioles.

The serrulate leaves of young plants are interesting. In the older plants they are entire, or serrulate above the middle; in the forest young trees up to 6 or 7 ft. high or more have been noticed with all the leaves serrulate throughout.

Silvicultural characters. The tree is a shade-bearer. It coppices well and reproduces freely from root-suckers, which are sometimes produced in quantity on swampy ground. Frost does not ordinarily occur within its habitat except in the extreme north; in the abnormal frost of 1905 it suffered severely in the Dehra Dun valley, where one tree was noticed to have been killed right down, but next year it shot up vigorously from the base. It is exacting as to soil, being found only on rich deep moist soil.

Artificial reproduction. Experiments at Dehra Dun have shown that owing to the large percentage of failure in the seed direct sowings cannot be relied on. Transplanting, however, is easy. The seed should be sown quite fresh in drills in fairly rich but porous soil about May–June, the beds being kept well weeded and watered, and sheltered from the sun in hot weather. The plants are ready for transplanting in the rainy season when two years old.

This tree can also be grown successfully from cuttings, which should be kept in the nursery and watered and shaded until well rooted.

ORDER XXVII. COMBRETACEAE

This order is one of great importance in Indian forestry, containing as it does several trees of considerable economic as well as silvicultural importance belonging to the genera *Terminalia* and *Anogeissus*. It also contains several climbers or scrambling shrubs of the genera *Combretum*, *Quisqualis*, and *Calycopteris*. Of these *Combretum decandrum*, Roxb., conspicuous by the large white bracts of the inflorescence, is a particularly noxious climber. It is common in parts of the sub-Himalayan tract, for example on the hill slopes round Kalsi on the Jumna, in Assam, Chittagong, Burma, Chota Nagpur, and in parts of the Indian Peninsula. It forms dense masses, suppressing young seedling and coppice growth and climbing into the crowns of trees. It is very difficult to deal with, as it grows rapidly and luxuriantly after cutting, and reproduces freely from seed, quantities of young seedlings appearing in the rainy season.

Genera 1. Terminalia, Linn.; 2. Anogeissus, Wall.; 3. Lumnitzera, Willd.

1. TERMINALIA, Linn.

This genus is of great importance both silviculturally and economically; it comprises ten Indian species, all trees, some of which reach large dimensions. The climatic and other requirements of the species vary considerably, *T. Oliveri* being confined to the driest parts of Burma, while others such as *T. myriocarpa*, *T. paniculata*, *T. bialata*, and *T. Catappa* are characteristic of the moister regions, the last named being essentially a littoral species. *T. tomentosa*, *T. Chebula*, and *T. belerica* are very widely distributed, while *T. Arjuna* is peculiarly restricted to the banks of streams, where, however, it is often abundant within its region.

The fruits vary. They are drupaceous in *T. belerica*, *T. Chebula*, and *T. Catappa*, ordinarily 5-winged in *T. tomentosa*, *T. Arjuna*, and *T. Oliveri*, unequally 3-winged in *T. paniculata* and *T. myriocarpa*, and broadly 2-winged in *T. bialata*. The germinative power of the seed is variable. In *T. Chebula* it is poor, in *T. belerica* usually good, while in the other important species it is more variable but often indifferent. Germination is hypogeous in *T. belerica* and epigeous in *T. tomentosa*, *T. Arjuna*, *T. Chebula*, and *T. myriocarpa*. The straggling habit of the young plant is a peculiar feature in certain species, notably *T. tomentosa*, *T. Arjuna*, and *T. myriocarpa*; young plants of *T. belerica* are erect.

Species 1. *T. belerica*, Roxb.; 2. *T. Chebula*, Retz.; 3. *T. tomentosa*, W. and A.; 4. *T. Arjuna*, Bedd.; 5. *T. myriocarpa*, Heurck and Muell. Arg.; 6. *T. Catappa*, Linn.; 7. *T. paniculata*, Roth; 8. *T. bialata*, Steud.; 9. *T. Oliveri*, Brandis.

1. **Terminalia belerica,** Roxb. Vern. *Bahera*, Hind.; *Tare*, Kan.; *Goting*, *bherda*, Mar.; *Tani*, Tam.; *Tandi*, Tel.; *Thitsein*, Burm. (Fig. 195.)

A large deciduous tree, attaining a height of 120 ft. and a girth of 10 ft. or more, usually with a straight tall bole; large trees are often buttressed at the base. Bark bluish or ashy grey, with numerous fine longitudinal cracks, yellow inside. Leaves broadly elliptical, 4–8 in. long, clustered at the ends of the branchlets. Wood yellowish grey, hard, not durable, but lasts fairly well under water, used for planking, packing-cases, boats, and other purposes. The fruits are used for tanning, but are inferior to those of *T. Chebula*.

Distribution and habitat. The tree is found in deciduous forests throughout the greater part of India and Burma, but not in arid regions. It is a common associate of the sal, the teak, and other important trees, occurring more or less scattered and not gregariously. In the Indian Peninsula it occurs most frequently in moist valleys. In Burma it is fairly common in deciduous forests both of the upper and of the lower mixed types, with or without teak.

In its natural habitat the absolute maximum shade temperature varies from 97° to 115° F., the absolute minimum from 30° to 60° F., and the normal rainfall from 40 to 120 in. or more.

Leaf-shedding, flowering, and fruiting. In northern India the leaves commence falling in some cases as early as November, some trees being almost leafless by the end of that month, while others may be in full leaf till the end of January. The trees remain leafless until March to May, when the new foliage appears. The spikes of small greenish white flowers appear in

April–May with the young leaves ; they have a strong honey-like smell, which is almost overpowering at times. The fruits (Fig. 193, *a*) ripen from November to February and fall during the cold and hot seasons. The fruit is a somewhat dry fleshy drupe 1–1·5 in. long, ovoid, pyriform, ellipsoidal or globose, grey velvety tomentose, with a hard thick-walled woody light yellow putamen 0·7–1·1 in. long (Fig. 193, *b*). The fruits are greedily eaten by monkeys, squirrels, pigs, deer, goats, and other animals, and are never allowed to lie long on the ground before being stripped of their fleshy covering: during the cold and hot seasons small clusters of the light yellowish fruit-stones may be found lying about the forest disgorged by deer in rumination. During the cold season the trees may often be seen with numerous withering branchlets, broken by monkeys in picking the fruits. The partiality of animals for the flesh of the ripe fruits is an assistance to the spread of the seed. On the other hand, much of the fruit crop is rendered ineffective by insects and animals. The immature fruits are attacked by insects during the rainy season, and may fall to the ground. The hard nuts of the fruits are very largely bored into by insects while lying on the ground, and the whole crop may be destroyed in this way. The nuts are also frequently broken open, for the sake of the kernel inside, by squirrels, pigs, and other animals, and in some localities it is rare to find a single sound nut on the ground by the beginning of the rainy season.

The germinative power of the seed is better than that of most species of this genus, and much better than that of *T. Chebula*. Tests carried out at Dehra Dun showed a fertility of 86–100 per cent. for fresh seed and 5–40 per cent. for seed kept one year.

GERMINATION (Fig. 193, *c–e*). Hypogeous, thus differing from that of the other species under consideration. The hard putamen splits into two halves, and the radicle emerges, a strong taproot soon establishing itself. Meanwhile the cotyledonary petioles elongate, curving in the process and separating sufficiently to enable the young shoot to issue from between them. The cotyledons and the remnants of the putamen remain in or on the ground.

THE SEEDLING (Fig. 193).

Roots: primary root long, thick, terete, tapering, light brown : lateral roots moderate in number and length, fibrous, distributed down main root. *Hypocotyl* not very distinct, 0·2–0·3 in. long, subterranean. *Cotyledons*: petiole 0·4 in. long, thick, fleshy, flattened, curved to side of stem : lamina 0·6–0·8 in. by 0·5–0·6 in., thick, fleshy, broadly ovate or nearly orbicular, auricled by a basal prolongation, convolute and remaining some time within the nut. *Stem* erect, terete, green, pubescent ; internodes 0·4–1·2 in. long. *Leaves* simple, exstipulate, first pair opposite, sub-opposite or alternate, subsequent leaves alternate, earlier leaves small, subsequent leaves increasing rapidly in size. Petiole 0·1–0·3 in. long. Lamina 0·9–5 in. by 0·5–3 in., elliptical or obovate, acute, base acute or tapering, entire, glabrous above, sparsely pubescent on veins beneath, venation arched reticulate.

The growth of the seedling during the first season is only moderate, a height of about 5–8 in. being ordinarily attained. Subsequently the development is more rapid, particularly if the plants are regularly weeded, for although they are capable of making their way through weeds their development is considerably impeded in the process. The young plants do not assume the

FIG. 193. *Terminalia belerica*—SEEDLING × $\frac{7}{8}$

a—Fruit b—Endocarp c - e—Germination stages f, g—Development of seedling during first season

straggling habit of some *Terminalia* species, but grow erect, producing strong side branches from the second year. A long stout taproot is formed, and develops considerably in the second year; plants only one year old, that is in the second season, have been dug up and found to have thick taproots as much as 3½ ft. long.

The seedlings stand fairly dense shade during the first year or two, but very heavy shade suppresses and kills them afterwards. Frost often affects the leaves, but ordinary frosts do not kill back the seedlings, particularly in grass. Hail tears the large leaves to pieces, as was observed in a severe hail-storm at Dehra Dun in February 1913. In northern India the season's growth stops in November–December, and new growth starts in March. The leaves turn yellow about November–December, and commence falling in December–January; by March they have usually all fallen.

The following measurements in experimental plots at Dehra Dun give some indication of the rate of growth of young plants under different conditions, and exhibit the marked effect of weeding:

Terminalia belerica: rate of growth of young plants, Dehra Dun.

Condition under which grown.	Height at end of season.				
	1st season.	2nd season.	3rd season.	4th season.	5th season.
(1) In nursery, weeded and watered	0 ft. 6 in.–0 ft. 8 in.				
(2) Transplants of 1st rains, not weeded or watered subsequent to transplanting	Maximum 0 ft. 6 in.	Maximum 1 ft. 6 in.	1 ft. 2 in.–2 ft. 0 in.	2 ft. 6 in.–3 ft. 7 in.	4ft. 11 in.–5ft. 8 in.
(3) Fruit scattered on ground as under natural conditions; subsequently weeded. Sunny locality	Maximum 0 ft. 5 in.	2 ft. 6 in.–3 ft. 2 in.	4 ft. 5 in.–10 ft.	Maximum 12 ft. 9 in. (girth 0 ft. 7 in.)	
(4) Fruit scattered on ground as under natural conditions; not subsequently weeded. Sunny locality	0 ft. 4 in.–0 ft. 7 in. (heavy grass and weeds)	0 ft. 7 in.–0 ft. 9 in.			
(5) Fruit scattered on ground as under natural conditions; not subsequently weeded. Sunny locality	Maximum 0 ft. 5 in.	Maximum 1 ft. 3 in.	Maximum 2ft. 7 in.	Maximum 5 ft. 10 in.	
(6) Fruit scattered on ground as under natural conditions; not subsequently weeded. Moderate side shade	Maximum 0 ft. 8 in. (heavy growth of weeds)	Maximum 0 ft. 11 in.			
(7) Fruit scattered on ground as under natural conditions; not subsequently weeded. Heavy shade	Maximum 0 ft. 6 in.	0 ft. 3 in.–0 ft.10 in.			

SILVICULTURAL CHARACTERS. The tree is a light-demander, though it can stand slight shade in youth. It is decidedly sensitive to frost, all records of severe frosts agreeing in this respect; the leaves are usually found to be touched by frost more readily than those of almost any of its associates. As regards drought it is somewhat more hardy, though it does not occur in very dry localities. In the abnormal drought of 1907 and 1908 in the sal forests of Oudh it proved to be fairly hardy, while it was not affected in the severe drought of 1899 and 1900 in the Indian Peninsula.

It coppices fairly well. Measurements made by Mr. C. M. McCrie at Ramgarh in the Gorakhpur district, United Provinces, showed an average varying from 1 to 2·5 shoots per stool in coppice coupes of different ages up to fifteen years old. Measurements made by me in 1911 in the Tikri forest, Gonda, United Provinces, gave for coppice one year old an average height of 5 ft., and an average of two shoots per stool, as against 4·7 ft. and 2·2 shoots

respectively for sal. Experiments in 1909 in North Chanda, Central Provinces, showed a poor pollarding capacity, while the results of coppice fellings were on the whole good; the percentage of stools which coppiced successfully in different months being: (1) April, nil; (2) May, 100; (3) June, 100; (4) July, 100; (5) September, 50.

Natural reproduction. The consumption of the fleshy portion of the fruit and the dissemination of the hard nuts by animals has already been alluded to. Where the flesh is not so consumed it rots off or is eaten off by white ants, the nuts often being wholly or partially buried in the process. Germination takes place at different times during the rainy season. Successful germination is greatly assisted if the nuts are buried by rain, by white ants, or otherwise, since the radicle of the germinating seedling is liable to be eaten by birds and insects or to dry up if exposed to the sun. A considerable degree of moisture is necessary to stimulate germination, and it has been found by experiment that germination takes place more readily in moist places under shade, particularly if the nuts are buried, than in places exposed to the sun.

The high germinative power of sound seed and the comparative ease with which the seedling establishes itself would indicate that the tree should be more gregarious than it is. There can be little doubt that its sporadic character is due to the fact that the seed is so much subject to the attacks of animals and insects that a comparatively small proportion reaches the germinating stage.

Artificial reproduction. Experiments in direct sowing have not been tried, but transplanting during the first rainy season, before the taproot has become too long, has proved quite successful. The nuts or the whole fruits should be sown in the nursery in March or April, covered with earth and watered regularly. Germination usually takes place about one to two months after sowing. Transplanting should be done in wet weather, and may be carried out either after pruning the stem and roots or with stem and roots intact; the latter gives the better results, the former checking the growth considerably.

Rate of growth. The rate of growth is moderate, or under favourable conditions rapid. The following records are available of girth measurements of trees in sal forest sample plots in the United Provinces:

Terminalia belerica: girth measurements in sample plots, United Provinces.

Forest division.	Locality.	No. of years under observation.	No. of trees under observation.	Girth classes. ft.	Mean annual girth incremen for the period. in.
Saharanpur	Dholkhand and Malowala	7 and 12	2	0–1	0·30
			1	3–4	0·86
South Kheri	Bhira range	8 and 9	1	1–2	0·38
			2	2–3	0·54
Lansdowne	Chaukhamb	17	6	$1\frac{1}{2}$–4	0·34
	Jogichaur	—	1	3–4	0·80
	Kauria	4	1	6–8	0·49
	Gewain	12	2	$1\frac{1}{2}$–3	0·10
Haldwani	Khonani	6	2	3–4	0·46

A tree raised from seed sown in 1901 by Mr. Haines in the forest garden at Chaibassa, Chota Nagpur, attained in sixteen years a height of 36 ft. and a girth of 2 ft. $1\frac{1}{4}$ in.

Gamble's specimens gave three to seven rings per inch of radius, representing a mean annual girth increment of 0·9 to 2·1 in., which is rapid.

As regards coppice, measurements by Mr. C. M. McCrie in 1910 in the Ramgarh coppice coupes, Gorakhpur, gave the following results :

Terminalia belerica : rate of growth of coppice, Ramgarh, Gorakhpur, United Provinces.

Age. years.	Mean girth. in.	Mean height. ft.
2	—	4
4	2	8
6	3	11
8	3·8	14
10	4·6	16·5
12	5·5	19
14	6·3	21

2. **Terminalia Chebula,** Retz. Syn. *T. tomentella*, Kurz. Myrabolan tree. Vern. *Harra*, Hind. ; *Hirda*, Mar. ; *Anale*, Kan. ; *Kadakai*, Tam. ; *Karaka*, Tel. ; *Panga*, Burm.

A moderate-sized to large deciduous tree with a rounded crown, spreading branches, and usually a short trunk, though in Burma it often grows tall and straight. Bark dark brown, often longitudinally cracked, exfoliating in woody scales. Wood very hard, fairly durable, used for building, agricultural implements, and other purposes. The tree is important mainly on account of its fruits, which are the best of the commercial myrabolans used for tanning.

Distribution and habitat. Throughout the greater part of India and Burma in mixed deciduous forests, extending into forest of comparatively dry types. It ascends to considerable elevations, up to 5,000 ft. in the outer Himalaya, and according to Bourdillon, up to 6,000 ft. in Travancore in localities where the rainfall is light. In Burma it occurs in deciduous forests both of the upper and of the lower mixed types, along with teak, *Terminalia tomentosa*, and their associates : it occurs also in *indaing* forest on laterite, along with *Dipterocarpus tuberculatus* and its companions. It extends to the borders of the dry zone of Burma, but is not a characteristic tree of the drier parts of that zone. It is found on a variety of geological formations, and on clayey as well as on sandy soil. In the Central Provinces it is particularly common on metamorphic rocks in open forest or village lands, but also occurs on other geological formations. In Bombay it is common on Deccan trap, and Talbot notes that on the laterite of the Mahableshwar plateau at 4,500 ft. it is one of the principal constituents of the low elfin-wood forest. It is also a characteristic tree of other special types of dry forest. Thus in the Goalpara district of Assam it is common in the *bhabar* tract fringing the base of the outer hills on deep boulder formation in mixture with sal and *Lagerstroemia parviflora* in a dry stunted type of forest of a pronounced deciduous character : again, in the Kangra valley it grows gregariously in rather stunted form on poor rocky ground at about 3,500 ft. elevation, either pure or mixed with *Pinus longifolia*.

In its natural habitat the absolute maximum shade temperature varies from 98° to 118° F., the absolute minimum from 30° to 60° F., and the normal rainfall from 30 to 130 in.

Leaf-shedding, flowering, and fruiting. In some localities the leaves commence falling in November, and by February or March the trees are usually leafless. The new leaves appear from March to May; they are light green or sometimes copper coloured. The spikes of greenish white flowers appear with the new leaves. In the Himalayan valleys flowering may take place as late as June. In the Central Provinces, Haines says flowering takes place to a small extent in July–August, in addition to the usual flowering in April–May.

The fruits ripen from November to March, according to locality, and fall soon after ripening. The fruit (Fig. 194, *a*) is a somewhat hard drupe 1–2 in. long, obovoid, ellipsoidal or ovoid, yellow to orange brown, sometimes tinged with red or black, 5-ribbed when dry; the nut (putamen) is 0·7–0·8 in. by 0·5–0·6 in., ovoid, pale yellow, rough, hard, sub-angular. For commercial purposes the fruits are collected when quite ripe and spread out in the sun until thoroughly dry. The fruit crop varies from year to year. About 35 to 45 fresh fruits, or 60 to 75 dry fruits, weigh 1 lb.

The germinative power of the seed is poor. The precise cause of this has not been ascertained; Mr. J. E. C. Turner,[1] writing of conditions in Bombay, says that germination is generally backward with regard to the ridged fruits, but that those known locally as *bhonga*, in which the fleshy portion has been transformed into a black powder, presumably by a fungus, germinate readily. Tests at Dehra Dun with whole fruits as well as with nuts from which the outer fleshy covering was removed, invariably gave poor results. The results were better in the shade than in the sun. It was also found that the seed retained its fertility to a small extent for one year.

Germination (Fig. 194, *b–f*). Epigeous. The hard putamen splits in two and the radicle emerges from one end; the cotyledonary petioles elongate, arching slightly and raising above ground the cotyledons, which are convolute in the seed and unroll on emerging. The young stem then issues from between the cotyledons, and the discarded pieces of the putamen remain in or on the ground.

The seedling (Fig. 194).

Roots: primary root moderately long, somewhat thin, terete, tapering, wiry, yellow turning brown: lateral roots moderate in number and length, fibrous, distributed down main root. *Hypocotyl* distinct from and much thicker than root, 0·3–0·6 in. long, somewhat compressed and quadrangular, yellow turning green, pubescent, scarcely emerging from the soil. *Cotyledons*: petiole 1–1·5 in. long, flattened above, yellow or pinkish turning green, tomentose: lamina 0·9–1 in. by 1·5–1·7 in., foliaceous, somewhat fleshy, reniform or broadly orbicular, apex truncate or retuse, base acute, entire, yellow at first, becoming green on expanding, pubescent near base on both surfaces, glabrous elsewhere, with three prominent and two less conspicuous veins from the base, veins prominently branched. *Stem* erect, zigzag at the nodes, terete, green, rusty pubescent; internodes 0·5–1·2 in. long. *Leaves* simple,

[1] Ind. Forester, xxxiii (1907), p. 362.

FIG. 194. *Terminalia Chebula*—SEEDLING × $\frac{5}{8}$

a—Fruit b - f—Germination stages g, h—Development of seedling during first season

alternate, exstipulate. First leaf sometimes under 0·3 in. long, ovate lanceolate, acute or acuminate, pubescent. Subsequent leaves with petiole 0·1–0·2 in. long, tomentose; lamina 0·8–4·5 in. by 0·5 –2 in., ovate, acute, entire, pubescent, bright green above, somewhat paler beneath, venation arched reticulate, lateral veins 4–10 pairs.

The young seedling of this species can be distinguished from those of *T. tomentosa* and *T. Arjuna* by the length of the hypocotyl and the cotyledonary petioles (see p. 519).

The growth of the seedling is comparatively slow, a height of about 4–8 in. being ordinarily attained by the end of the first season, increasing to 1–2 ft. by the end of the second season. The year's growth ceases about November; the leaves commence falling that month, and the seedling is leafless in January–February, new growth commencing about March (Dehra Dun). Young plants are fairly frost-hardy.

Silvicultural characters. The tree is a light-demander, though in youth it stands slight shade and even benefits by side protection from the sun. It is fairly hardy against frost as well as drought. It withstands fire well, and has good powers of recovery from burning. It coppices fairly well.

Natural reproduction. The fallen fruits often become partially buried by rain, the soil round them being blackened with the tannin they contain. The fleshy portion becomes partly eaten by white ants or disintegrates, leaving the hard nut exposed. Germination takes place in the rainy season, sometimes not until the end of that season, or in some cases not until the following year. The scarcity of natural reproduction in some localities is very noticeable, and is a matter which requires further study. Where the collection of myrabolans is carried out extensively, the removal of the fruits would be sufficient to account for it. On the other hand, the lack of reproduction may be attributable to some extent to the poor germinative power of the seed and to the fact that it is much subject to the attacks of insects, rats, and squirrels. Numerous fruit-stones found lying ungerminated after the end of the rainy season have been split open, and almost invariably the seed has been found to be destroyed by insects. The seed germinates better if it has become covered with earth or débris than if it is lying in the open.

Artificial reproduction. Sowings on mounds, in patches or trenches, and otherwise have been carried out for years, but with very indifferent success, owing in part at least to the poor germinative power of the seed and to its liability to the attacks of insects, squirrels, and rats.

Experiments at Dehra Dun showed that transplanting from the nursery can be carried out successfully in the first or second rainy season. The most successful method of raising plants in the nursery was found to be by drying the fruits thoroughly, removing the hardened fleshy covering, and sowing the fruit-stones in boxes before the rainy season, covering them with earth and watering them regularly. Even with this treatment a success of only 20 per cent. was attained. Soaking the fruits in moist manure for some days was found to have no effect in stimulating germination. For artificial reproduction the fruits should be collected from the ground as soon as they fall, and not off the tree.

RATE OF GROWTH. The rate of growth is slow. The following measurements of trees in sal forest sample plots have been recorded :

Terminalia Chebula : records of girth measurements in sample plots.

Province.	Forest division.	Locality.	No. of years under observation.	No. of trees under observation.	Girth classes.	Mean annual girth increment for the period.
					ft.	in.
United Provinces	Dehra Dun	Nagsidh and Thano	17 and 20	6	1–2	0·25
				4	2–3	0·29
				2	4–5	0·37
,,	Lansdowne	Chaukhamb	17	11	1½–6	0·56
,,	,,	Jogichaur	4	1	1½–3	0·38
,,	,,	Barswar	4	15	1½–3	0·27
,,	South Kheri	Bhira (Kishanpur)	9	1	1–2	0·22
				1	2–3	0·12
Bihar and Orissa	Singhbhum	Tirilposi	18	2	3–4	0·70
				1	4–5	0·67
Central Provinces	Balaghat			30	2–3	0·16

Gamble's specimens showed six to ten rings per inch of radius, representing a mean annual girth increment of 0·63 to 1·05 in.

Coppice measurements showed an average height of 8 ft. and 8·5 ft. in five years in Dehra Dun and Gorakhpur respectively.

3. **Terminalia tomentosa,** W. and A. Vern. *Sain, ain, saj, asna, asan,* Hind. ; *Matti,* Kan. ; *Sadada,* Guz. ; *Maddi, nallamaddi,* Tel. ; *Karra marda,* Tam. ; *Taukkyan,* Burm.

A large deciduous tree with a long clean bole and a full crown. Bark grey to black, with deep longitudinal fissures and transverse cracks dividing it into oblong scales, red inside. Wood dark brown with darker streaks, hard, strong, of variable durability, used for building, carts, railway wagons, mine props, bedsteads, and other purposes : it lasts well under water.

The thickness of the bark varies with size and other conditions : the following figures give the average of a number of measurements made in the Dehra Dun district :

Girth of tree.	Bark thickness.	Girth of tree.	Bark thickness.
	in.	ft.	in.
0–6 in.	0·2	3–4	1·0
6 in.–1 ft.	0·35	4–5	1·1
1–2 ft.	0·5	5–6	1·1
2–3 ft.	0·8	6–7	1·2

Apart from its economic value the tree is important silviculturally as being one of the commonest of Indian forest trees and being suitable for afforesting clayey ground. In favourable localities it attains a girth of 12 ft. or more and a height of over 100 ft., but on dry rocky ground and other unfavourable situations it is stunted.

It is somewhat variable, particularly as regards its leaves, which as a rule are large and tomentose in less favourable localities and smaller and more glabrous in localities in which it grows best.

DISTRIBUTION AND HABITAT. *General distribution.* *Terminalia tomentosa*

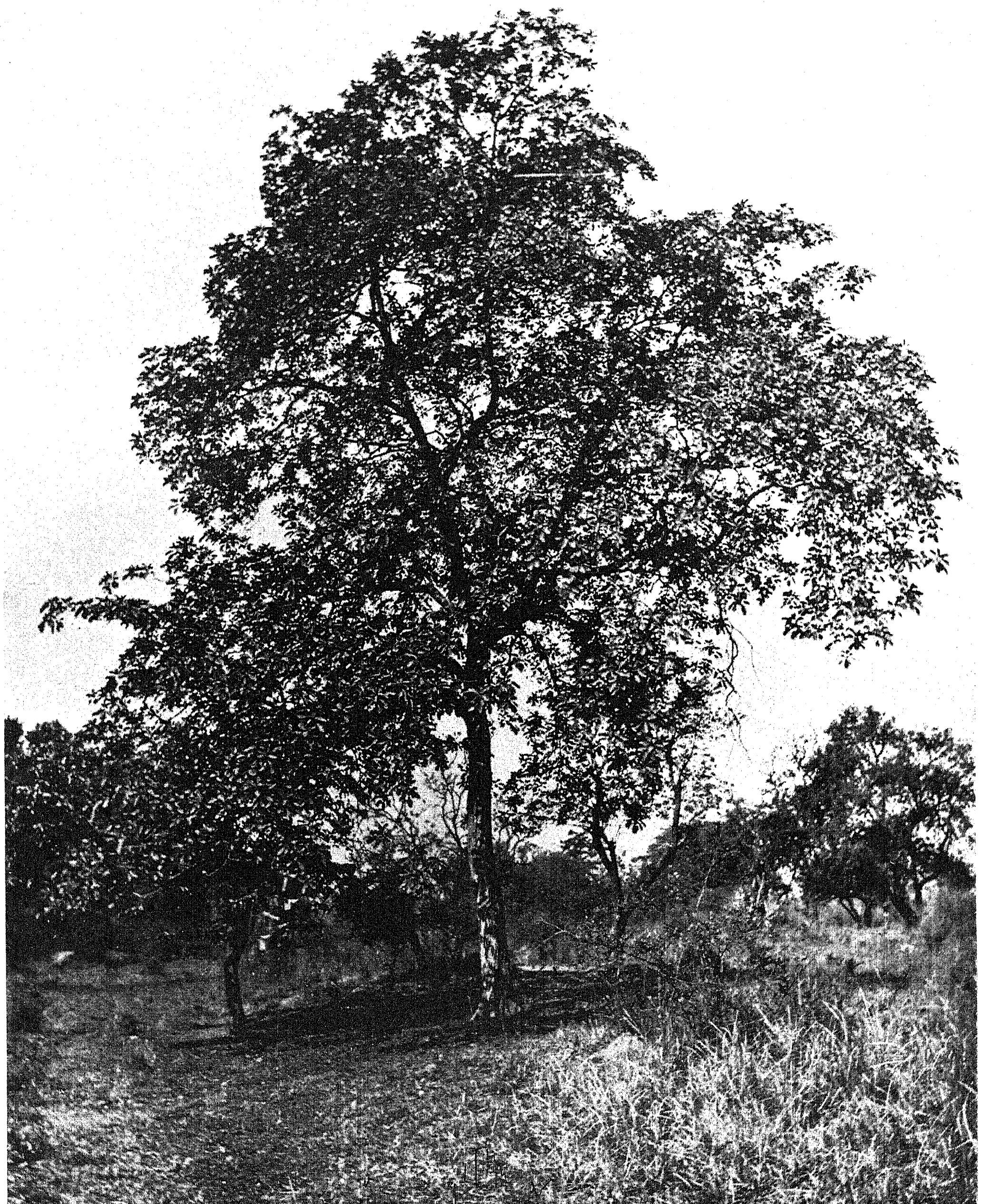

FIG. 195. *Terminalia belerica*, United Provinces.

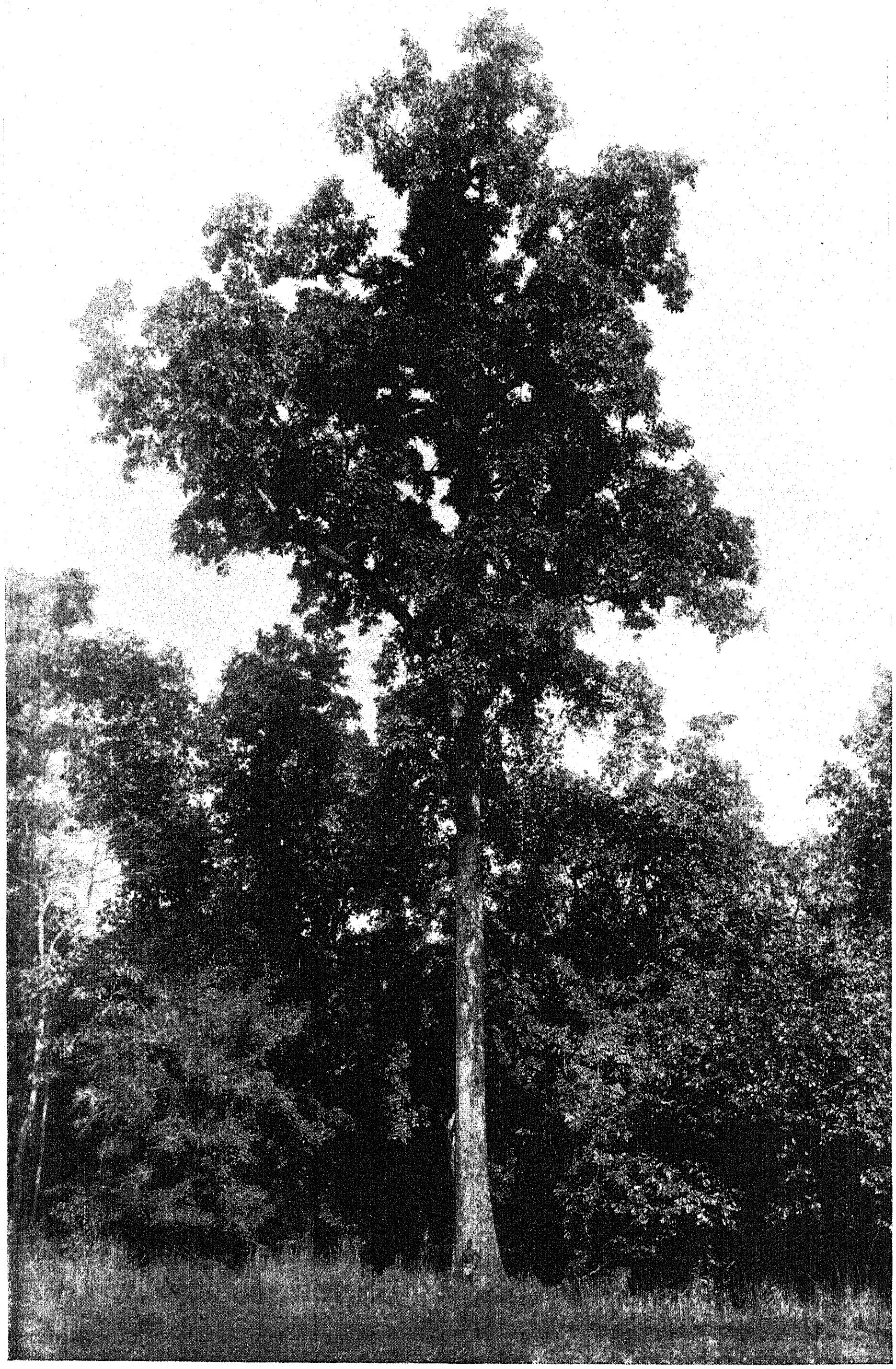

FIG. 196. *Terminalia tomentosa*, tree 12 ft. 4 in. in girth and 115 ft. in height on alluvial ground, Gonda district, United Provinces.

is one of the commonest and most widely distributed of Indian forest trees. It extends throughout the sub-Himalayan tract from the Ravi eastwards, ascending the outer hills to 4,000 ft. : it is not common east of the Jalpaiguri district of Bengal, and is rare in most parts of Assam. It is not found in Sind and Rajputana, but is common throughout the greater part of the Indian Peninsula, extending into comparatively dry regions. It is plentiful throughout the greater part of Burma, extending into the dry zone and ascending to 4,000 ft. in the Southern Shan States.

Climate. In its natural habitat the absolute maximum shade temperature varies from 95° to nearly 120° F., the absolute minimum from 30° to nearly 60° F., and the normal rainfall from 30 to 150 in.

Soil. The tree attains its largest dimensions on deep rich alluvial soil. On poor shallow soil, particularly on hilly ground, though often plentiful it remains stunted. It favours stiff clayey soil, where it often becomes gregarious in depressions and round the edges of swamps. It grows freely on black cotton soil, though it remains stunted. It is abundant on laterite in some localities, though here also it is stunted.

Local distribution and forest types. Sub-Himalayan tract. In the sub-Himalayan tract *Terminalia tomentosa* is abundant in the sal forests, becoming gregarious on flat clayey ground and in grass-covered depressions which usually mark the sites of former ponds or watercourses and which have gradually filled up. In such places it is probable that the tree acts as a useful draining agent, for it is noticeable that sal reproduction eventually makes its way into these areas underneath it. That it is not specially partial to badly drained clayey ground, though it is capable of growing there, is shown by the fact that it occurs in quantity and shows its best development on well-drained ground. In the sal forests, besides the sal (*Shorea robusta*) its principal associates are *Lagerstroemia parviflora*, *Terminalia belerica*, *Adina cordifolia*, *Ougeinia dalbergioides*, *Anogeissus latifolia*, *Stereospermum suaveolens*, *Eugenia Jambolana*, *E. operculata*, and *Buchanania latifolia*.

A special type of forest, in which *Terminalia tomentosa* occurs pure or mixed with *Anogeissus latifolia* on rich alluvial ground beside rivers, is a feature of some of the submontane forests and is well exemplified in the Gonda district of the United Provinces. The evolution of this type is explained on p, 523 under 'natural reproduction' and is shown in Figs. 197–200. Fig. 200 gives a good idea of the appearance of a crop of this type approaching maturity. On rich alluvial ground of this kind it reaches magnificent proportions, as may be judged from Fig. 196, showing a tree 12 ft. 4 in. in girth and 115 ft. high.

In the Siwalik hills and outer Himalaya it is common and sometimes gregarious, often on somewhat poor soil, but here it reaches only a small size. In the Himalaya it ascends to about 4,000 ft. It extends westward to the Kangra hills, and possibly to a small extent farther west.

In the eastern part of the sub-Himalayan tract it reaches very large dimensions, for instance in the Tista forests, where it occurs both in sal forest and in low-level mixed forest without sal. In Jalpaiguri it is not plentiful, though there are some well-grown trees in the Upper Tondu forest : east of this district it is not common, and is more often absent altogether. In the

Bengal Duars it mixes with *T. myriocarpa*, but farther east the latter replaces it largely if not entirely.

Chota Nagpur. In Chota Nagpur the tree is common, particularly in valleys and moist localities. On village lands it is very common, and is extensively pollarded for the cultivation of the tasar silkworm. It is a common constituent of the sal forests, while in some valleys it occurs along with *Bombax malabaricum* and other species without sal, probably owing to insufficient drainage.

Central Provinces and Berar. *Terminalia tomentosa* is common in deciduous forests throughout the greater part of the Central Provinces and Berar; it is a common companion of the sal as well as of the teak. It is plentiful on black cotton soil, which many species avoid, but here it is usually small. It reaches its best development on moist fertile alluvium near rivers, where it sometimes tends to be gregarious.

In the usual mixed deciduous type, in which teak may or may not be present, its chief companions are *Pterocarpus Marsupium*, *Terminalia belerica*, *T. Chebula*, *T. Arjuna* (along streams), *Anogeissus latifolia*, *Ougeinia dalbergioides*, *Bassia latifolia*, *Lagerstroemia parviflora*, *Diospyros Melanoxylon*, *Buchanania latifolia*, *Soymida febrifuga*, *Adina cordifolia*, *Dalbergia latifolia*, *Cleisanthus Collinus*, *Chloroxylon Swietenia*, *Butea frondosa*, as well as many other species of less importance. Sometimes a special type is found in moist valleys on flat ground where the soil is fair to good and often clayey, the chief associates being *Cleistanthus Collinus*, *Bassia latifolia*, *Anogeissus latifolia*, *Ougeinia dalbergioides*, *Buchanania latifolia*, and a few other species.

Bombay. *Terminalia tomentosa* is plentiful in most of the forest tracts of the Bombay Presidency, being perhaps nowhere more abundant than in Kanara and in the Dangs forests of Surat; in parts of the latter forests there are sometimes as many as 30 mature trees per acre, while in the Mungod high forest of the East Kanara division it forms 23 per cent. of the crop. In Kanara it grows better on granite and schist than on laterite. In the Deccan it prefers black cotton soil to the shallow soils of the quartzite hills so frequent in that region. It occurs in nearly all types of mixed deciduous forest, ascending to between 3,500 and 4,000 ft. on the Nasik ghats and the Khandesh Akrani, but is absent from the laterite of the Mahableshwar plateau. It thrives best in the moister localities, particularly in valleys on alluvial ground, becoming gregarious on clayey soil. At the higher elevations, in exposed situations and on poor soil, it becomes stunted. In the Kanara forests, where the number of species is considerable, its most important companions are teak, *Dalbergia latifolia*, *Lagerstroemia lanceolata*, *L. parviflora*, *Xylia xylocarpa*, *Pterocarpus Marsupium*, *Anogeissus latifolia*, *Terminalia paniculata*, and *Adina cordifolia*. It shows a marked tendency to occupy the more level ground where the soil is deep and moist. In the mixed forests of somewhat drier localities it is found with teak, *Anogeissus latifolia*, *Lagerstroemia parviflora*, *Bassia latifolia*, *Ougeinia dalbergioides*, *Buchanania latifolia*, *Diospyros Melanoxylon*, *Dalbergia latifolia*, *Cassia Fistula*, *Phyllanthus Emblica*, and many other species.

Southern India. Although not so common as in Bombay, the tree is fairly

FIG. 197. *Terminalia tomentosa*, establishment of pure crops on alluvial ground, Gonda district, United Provinces: (1) natural seedlings up to 20 ft. high appearing on comparatively recent alluvium.

FIG. 198. *Terminalia tomentosa*, establishment of pure crops on alluvial ground, Gonda district, United Provinces: (2) natural reproduction up to 8 ft. high; older forest of *Terminalia tomentosa* on older alluvium behind.

Fig. 199. *Terminalia tomentosa*, establishment of pure crops on alluvial ground, Gonda district, United Provinces: (3) young crop about 15 ft. high; older alluvial crop on left behind.

Fig. 200. *Terminalia tomentosa*, establishment of pure crops on alluvial ground, Gonda district, United Provinces: (4) forest approaching maturity.

well distributed in Madras, and in some localities it is plentiful. It is characteristic of various types of mixed deciduous forest, and in Ganjam is a common companion of the sal. It is fairly plentiful in the Wynaad, and ascends to 4,200 ft. in the Nilgiris. In Coorg it is one of the commonest species in the deciduous forests, and attains very fair dimensions. It is common in many parts of Hyderabad and Mysore, and is very common in Travancore up to 2,000 ft.

Burma. *Terminalia tomentosa* is common in most of the mixed deciduous forests throughout Burma, both in the upper and in the lower mixed types, as well as in *indaing* (dry dipterocarp) forest. It is sometimes found in dense evergreen forest, for example on alluvial flats along streams in some parts of the Upper Chindwin, but here the evergreen has probably encroached on a former deciduous type of forest.

In the upper mixed forests, which are found on hilly or undulating ground, it is characteristic more of the dry than of the moist types, its chief companions being teak, *Xylia dolabriformis*, *Acacia Catechu*, *Sterculia* spp., *Homalium tomentosum*, *Dalbergia cultrata*, *Terminalia Chebula*, *Vitex glabrata*, *Pterocarpus macrocarpus*, *Odina Wodier*, *Adina cordifolia*, *Anogeissus acuminata*, and others, and in the drier parts *Pentacme suavis* and *Shorea obtusa*. The chief bamboos are *Dendrocalamus strictus* in the driest types, *Bambusa polymorpha* in the moister types, and in intermediate types *Cephalostachyum pergracile*, and in Upper Burma *Thyrsostachys Oliveri*; *Bambusa Tulda* often occurs with it on alluvial flats.

It is very plentiful in certain types of lower mixed forest on flat alluvial land tending towards dry rather than moist conditions. A case in point is the Satpôk forest of the Tharrawaddy district, where after teak it is the commonest tree, these two species being far more plentiful than any other. Although flat, the locality is fairly well drained; the chief associate species are *Xylia dolabriformis*, *Lagerstroemia Flos-Reginae*, *Berrya Ammonilla*, *Adina cordifolia*, *A. sessilifolia*, *Stephegyne diversifolia*, *Terminalia Chebula*, *T. belerica*, *Odina Wodier*, *Eugenia Jambolana*, and *Eriolaena Candollei*. The rainfall in this tract is about 80 in.

The following figures based on complete enumerations in the Satpôk forest give some idea of the prevalence of this tree in some of the compartments:[1]

Stock of *Terminalia tomentosa* trees in certain compartments in the Satpôk forest, Tharrawaddy district, Burma.

Compartment No.	Area in acres.	Number of trees. I 7 ft. girth and over.	II 6 to 7 ft. girth.	III $4\frac{1}{2}$ to 6 ft. girth.	IV 3 to $4\frac{1}{2}$ ft. girth.
2	178	192	250	470	508
4	178	235	283	383	437
8	178	176	173	357	717
9	178	128	141	214	487
24	178	122	114	295	524
25	178	177	193	310	372

[1] Working Plan for the Satpôk, Sitkwin, and Thindawyo Reserves, Tharrawaddy, R. S. Troup, 1906.

The tree extends into the open scrub forests of the dry zone of Upper Burma, but even outside that zone it is characteristic of certain dry types of poor open bamboo forest on shallow soil, where the trees attain small dimensions. This type is exemplified in parts of the Ruby Mines district, where the chief associate species are *Xylia dolabriformis*, *Pterocarpus macrocarpus*, *Diospyros burmanica*, *Acacia Catechu*, *Adina cordifolia*, *Odina Wodier*, and others, with *Terminalia Oliveri* in the drier parts; the chief bamboo is *Dendrocalamus strictus*. In the dry zone proper the rainfall varies from 22 in. to about 50 in., but it is doubtful if the tree occurs in tracts where it is less than 30 in. The geological formation consists mainly of soft sedimentary unaltered sandstones and shales. *Terminalia tomentosa* is common, but its growth is stunted; its chief associates are *Terminalia Oliveri*, *Tectona Hamiltoniana*, *Acacia Catechu*, *A. leucophloea*, *Buchanania latifolia*, *Diospyros burmanica*, *Odina Wodier*, *Schleichera trijuga*, and sometimes *Xylia dolabriformis* of small size.

A variety with larger leaves and fruits (var. *macrocarpa*, Kurz) is characteristic of *indaing* forest, chiefly on laterite, in association with *Dipterocarpus tuberculatus*, *Pentacme suavis*, *Shorea obtusa*, *Melanorrhoea usitata*, *Buchanania latifolia*, *Diospyros burmanica*, and other species. Where the soil becomes stiff and clayey *Terminalia tomentosa* becomes the predominating species and may form entirely pure crops, often of an open description with a soil-covering mainly of grass.

LEAF-SHEDDING, FLOWERING, AND FRUITING. In northern India the leaves usually commence falling in January or February, and by March or April, and in dry places as early as February, the trees are leafless, though the dead leaves sometimes hang on the trees for some time. This is one of the latest forest trees to acquire its new foliage, and in northern India the new leaves only begin to appear about the end of June. Farther south they appear about April–May. The panicled spikes of small whitish flowers appear about July in northern India and about May–June farther south. In the early part of the rainy season a forest of *Terminalia tomentosa* is a beautiful sight with the masses of whitish blossom against the delicate green of the young foliage. The fruits form rapidly, becoming full-sized by about October, though still green; they remain pale yellowish green from November to January, ripening about February–March. The fruit (Fig. 201, *a*) has a hard bony axis with five coriaceous wings, and is brown when ripe. The ripe fruit falls chiefly from March to May, but many unripe fruits, usually found to be bitten off by insects or possibly birds, fall during January–February, and turning brown after falling give the false impression of being ripe. Parrots often destroy much of the fruit crop prematurely. The ovary is often attacked by a *Cynips*, which prevents the formation of the fruit and produces bunches of galls which may be mistaken for fruits, though they have no resemblance to the characteristic winged fruits.

So far as tests show, the percentage of fertility of the seed is comparatively low. In a number of tests carried out at Dehra Dun the maximum percentage obtained was only 45, except in one case in which 78 per cent. was obtained. Possibly these poor results are due partly to the difficulty in discriminating between good and bad (i. e. prematurely fallen) seed when the fruits are

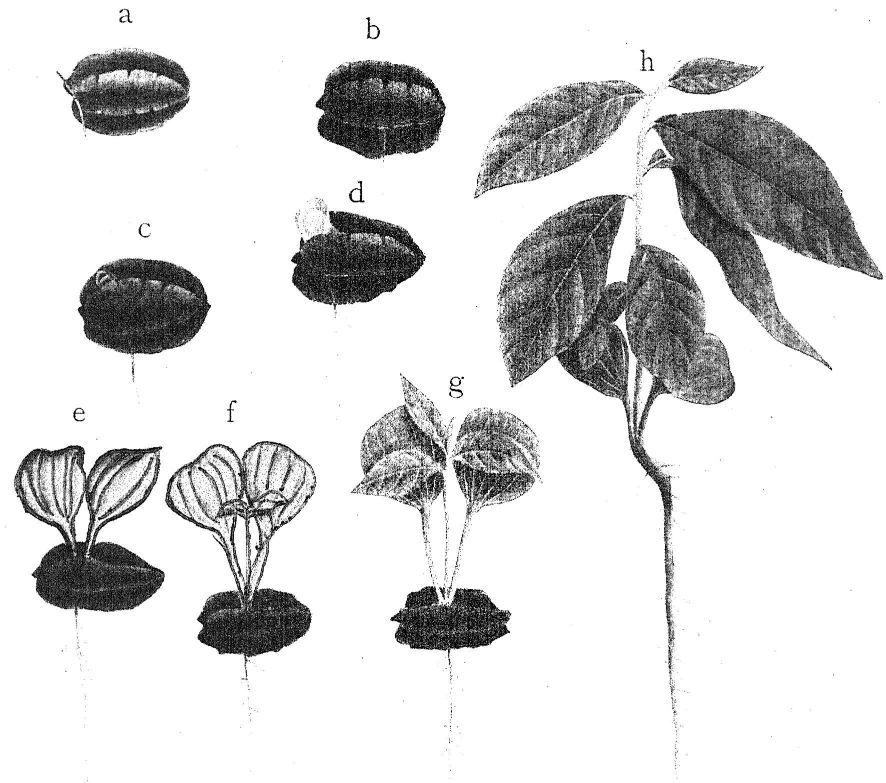

FIG. 201. *Terminalia tomentosa*—SEEDLING × $\frac{3}{8}$

a—Fruit   b - e—Germination stages   f - h—Development of seedling to end of first season

collected from the ground, but in any case this would represent the actual conditions so far as natural reproduction is concerned. In seven different samples of fruits from northern India the number weighing 1 lb. varied from 150 to 250.

Records of seed-years extending over a series of years in various localities show that fair to good seed-years are the rule, though occasional bad seed-years occur at varying intervals.

GERMINATION (Fig. 201, *b–e*). Epigeous. The hard endocarp of the fruit opens slightly and the radicle emerges. The cotyledonary petioles elongate by arching and the large foliaceous cotyledons, which are convolute in the seed, extricate themselves and unroll. The cotyledons are raised above ground by the further elongation of their petioles, from between which the young shoot emerges.

THE SEEDLING (Fig. 201).

Roots: primary root moderately long and thick, terete, tapering, brown, upper part, immediately below ground-level, swollen, with a characteristic bend due to the efforts of the seedling to escape from the hard endocarp of the fruit during germination; lateral roots moderate in number and length, fibrous, distributed down main root. *Hypocotyl* distinct from root, 0·2 in. long, green, immediately below or on surface of ground. *Cotyledons*: petiole 0·8–1·5 in. long, flattened above, green, pubescent: lamina 1·2–1·4 in. by 1–1·5 in., foliaceous, somewhat fleshy, broadly and often obliquely obovate orbicular, apex truncate or retuse, base tapering and slightly decurrent, bright green, glabrous, with five prominent veins from the base. *Stem* erect, terete, green, tomentose; first internode, above cotyledons, 1·8–2·5 in., subsequent internodes 0·1–0·7 in. long. *Leaves* simple, exstipulate, alternate, rarely sub-opposite, first pair not opposite. Petiole 0·1–0·2 in. long, tomentose. Lamina 1·3–4 in. by 0·8–1·6 in., elliptical ovate or obovate, apex and base acute, entire, pubescent or glabrescent above, pubescent beneath, tomentose round margin and on principal veins beneath, lateral veins 6–8 pairs in young seedlings; two small glands present, one on either side of midrib near base of lamina on under surface.

The cotyledons of *T. tomentosa*, *T. Arjuna*, and *T. Chebula* are somewhat similar, but in the germinating stages the seedlings can be readily distinguished by the lengths of the hypocotyls and cotyledonary petioles, thus:

Cotyledonary petioles short (0·3–0·6 in.); hypocotyl long (2·2–3 in.)—*T. Arjuna*.

Cotyledonary petioles long (0·8–1·5 in.); hypocotyl moderately long (0·3–0·6 in.)—*T. Chebula*.

Cotyledonary petioles long (0·8–1·5 in.); hypocotyl very short (0·2 in.)—*T. tomentosa*.

During the first season the growth of the seedling is only moderate, a height of 4–7 in. being ordinarily attained under natural conditions, while even with regular watering and weeding a height of more than 1 ft. is seldom reached, though occasionally a height of 18 in. or more may be attained. The taproot reaches a length of about 6–10 in. within two months of germination. In the subsequent growth of the young plant height is sacrificed to a branching or straggling growth, long branches being produced which bend over towards the ground, and no definite upward leader being formed for

some time ; this form of straggling or bushy growth is characteristic of certain other species of *Terminalia*, e. g. *T. Arjuna* and *T. myriocarpa*.

The seedlings are fairly hardy against drought, but are more sensitive to frost. They stand moderate side shade, but are intolerant of heavy overhead shade ; in experimental plots at Dehra Dun it was found that few seedlings survived heavy shade more than one season, while all succumbed before the end of the second season. The cotyledons are subject to the attacks of birds, and the seedlings are browsed by deer and cattle and are uprooted by pigs.

In the forest, seedlings of *Terminalia tomentosa* often pass unrecognized, since the leaves of young seedlings are very different from those of older plants, the leaves being much smaller, more pointed, and more conspicuously hairy. A characteristic feature of seedlings of the first year is a swelling and decided bend where the taproot joins the stem immediately below ground-level, at the point where the seedling escaped from the hard fruit during germination.

SILVICULTURAL CHARACTERS. *Terminalia tomentosa* is a light-demander, and is rapidly suppressed under shade. It cannot be called exacting as regards soil, being found on a variety of soils, and sometimes on dry hills with poor shallow soil. Although capable of existing on stiff clay better than most species it does not follow that this type of soil suits it best, for its development on deep well-drained soil is better.

In years of severe drought the tree has proved decidedly tender. In the abnormal droughts of 1899 and 1900 in the Indian Peninsula and 1907 and 1908 in Oudh it was badly affected, but in the latter case the sal suffered more severely than it did. As regards frost, the leaves are readily killed, but the damage is often more apparent than real, since the stems frequently remain untouched when all the foliage is withered. Young plants are, however, often killed back in frosty localities.

Young plants suffer less than sal from grazing, probably because they lose their leaves in the hot season, at which time the sal plants send up succulent young shoots. Mr. J. Best [1] describes a curious form of growth due to excessive grazing in the Bhandara district of the Central Provinces. Considerable areas are covered with plants up to 18 in. in height, much branched and stunted in growth. On being dug up they are found to have a thick and distorted stem at or just beneath ground surface. This stunted growth is attributed more to trampling and hardening of the soil than to actual browsing, and it is pointed out that on steep hills where cattle do not graze this stunted growth is absent.

The tree has a deep root-system. It sometimes produces root-suckers where the roots are exposed, but as a rule sparingly. Trees up to medium size generally coppice and pollard well, but the coppicing power of trees more than about 4 ft. in girth is usually poor : stools of this size sometimes make a dying effort by producing an immense mass of small coppice-shoots and then succumb. In some districts, particularly in parts of Chota Nagpur, the Central Provinces, and elsewhere the tree is regularly pollarded for the growing of tasar silk : in parts of Bombay it is extensively lopped for ash manure

[1] Ind. Forester, xxxv (1909), p. 612.

for crops, while in some localities it is lopped for cattle fodder. The coppicing and pollarding power appears to vary. Experiments carried out in the Chanda district of the Central Provinces in 1909 showed that of eleven different species coppiced and pollarded *Terminalia tomentosa* showed the poorest results under either method. As regards coppice, the percentage of stools which produced shoots when cut in different months from April to September was: April, 66; May, 66; July, 40; August, nil; September, nil. Coppicing experiments in North Khandesh, Bombay, in 1903 showed that 70 per cent. of the trees yielded coppice-shoots, 1–9 shoots per stool. Measurements which I made in 1911 in three coppice coupes one and two years old in the Gonda district, United Provinces, showed that out of 17 species *Terminalia tomentosa* showed the largest average number of shoots per stool in each of the coupes, namely 4·7 in the one-year-old coupe, and 4·7 and 2·9 in two coupes two years old.

A curious form of injury very prevalent among trees on the western side of the Indian Peninsula from North Kanara southwards to Malabar is that known as water-blister. This so-called blister is a ridge-like swelling on the side of the tree, apparently resulting from the healing over of a longitudinal crack in which sap or water has accumulated, so that when the blister is cut into a quantity of yellowish fluid is forced out under considerable pressure. There may be one or more blisters on a tree.

Natural reproduction. The natural reproduction of this important tree is not yet fully understood. Considering the comparatively low germinative power of the seed, the wide distribution and relative abundance of the species is remarkable, and points to some compensating advantage in its power of establishing itself under varying conditions. In forest tracts young seedlings may be found in large quantities after a good seed-year, indicating that even if a considerable proportion of the seed fails to germinate, the seedlings which survive from seed which does germinate are sufficiently plentiful.

Numerous experiments have been carried out at Dehra Dun to ascertain the conditions which favour natural reproduction, and so far as they go these experiments have shown that germination, which takes place early in the rains, is more successful on bare ground than where the fruits are scattered on grass or on low weeds. Although germination takes place fairly readily in the case of fruits lying on the surface of the ground, there is a higher percentage of success if they are slightly buried, as often happens under natural conditions on loose soil during the early showers preceding the rainy season. Moisture greatly stimulates germination, and thus the seed may germinate freely under the densest shade, though the seedlings do not survive for more than one season if the shade is at all heavy. Successful germination as well as establishment of seedlings is possible in the case of fruits lying on a layer of dead leaves both in the sun and under shade; this is not the case with sal, which fails to germinate on a layer of dead leaves in the sun, while under shade, although germination takes place, the seedlings do not survive more than one season where the leaf layer is thick. In a damp sodden growth of weeds the seedlings tend to rot during the first rainy season: otherwise they are capable of making their way through a moderate growth of grass and low weeds.

The effects of light and shade and of soil-covering at the time the fruit falls are indicated by the following results of experiments in six plots in the same locality at Dehra Dun :

Terminalia tomentosa : survival and development of seedlings.

Condition of plot.	Percentage of germination (100 fruits scattered in each plot).	Percentage and condition of survivors at end of first season.	
(1) In full sunlight : on bare ground, not weeded subsequently	42	40	Seedlings up to 6 in. high ; plots covered with grass up to 1 ft. high.
(2) In full sunlight : on short grass	14	12	
(3) In moderate side shade : on bare ground, not weeded subsequently	29	28	Seedlings healthy, up to 5½ in. high ; ground moist with heavy dew ; grass and weeds about 9 in. high.
(4) In moderate side shade : on short grass	5	4	
(5) In dense overhead shade : on bare ground, not weeded subsequently	45	14	Of which only 2 healthy, 4 in. high, on side of plot near light ; remainder dying.
(6) In dense overhead shade : on short grass	29	6	Up to 5 in. high, only on side of plot near light.

The effect of light on natural reproduction has been further brought out in two plots in close proximity to each other at Dehra Dun, one plot being under the fairly heavy shade of bamboos and the other in the open. These plots were laid out with the view of ascertaining if sal seed scattered on the surface of a thick layer of leaves would germinate and the seedlings would establish themselves under shade and in the open respectively. The leaves in question were collected in the forest, and among them were a number of fruits of *Terminalia tomentosa.* In the shaded plot several seedlings appeared from these fruits during the rainy season in July and August : germination was very successful owing to the wet layer of leaves. Of the seedlings which appeared the survivals were only 4 in November, 2 in December, 1 in January, 1 in March, and none in July. It is probable that the mortality was due not only to shade but also to want of moisture, since the ground became decidedly dry after the rainy season was over ; this, however, would also hold under similar conditions in the forest. In the open (unshaded) plot ten seedlings appeared : although some of the fruits germinated on the dry upper layer of the dead leaves a number failed to do so, and this indicates that a thick layer of dead leaves in the open may prevent reproduction to some extent, though to nothing like the extent which it does in the case of sal, for the sal fruits fall after the season of leaf-shedding, whereas those of *Terminalia tomentosa* fall in the early part of it and therefore do not lie on the top of the leaves. These ten seedlings all survived, and by October of the second year varied from 1 ft. 5 in. to 4 ft. 2 in. in height ; some were amongst grass about 2 ft. high and others were quite in the open. This experiment clearly demonstrates the necessity for an abundance of light for successful natural reproduction.

To summarize, it may be said that these preliminary experiments indicate the following to be some of the main factors which favour the establishment of natural reproduction : (1) abundance of light, (2) a fair degree of soil moisture, (3) bare ground, (4) loose soil, enabling the fruits to be slightly

covered during the early showers, (5) absence of dense sodden grass and weed-growth. The influence of frost, fire, and grazing will be alluded to below.

Confirmation of the results of these preliminary experiments may frequently be met with by observations in the forest. The effect of light in particular is constantly noticeable. Vigorous young seedlings appear in quantity along roads, paths and fire-lines, and on open spaces. Dense masses of saplings establish themselves in gaps with complete overhead light, and the stronger ones eventually suppress the weaker.

An instance of the result of admitting light and clearing the ground is recorded in the Burma Forest Report for 1914–15, where it is stated that good natural reproduction resulted from the burning of an area in Toungoo in which the bamboo had flowered; this area had previously been fire-protected for many years.

A good instance of the value of loose soil was observed a few years ago in the Gonda district of the United Provinces, where vigorous seedlings appeared in large numbers in the loose earth washed down along the base of the ridge of earth thrown up alongside a new boundary trench. The abundance of the seedlings was due to the fruits having been washed against the base of the ridge and partially covered with soil, and indicates that surface water in the rains is an important distributing agency; the vigour of the seedlings was apparently due to the loose earth in which they grew. Similarly in loose bare earth along the sides of cart tracks in the forest seedlings are often found in great abundance.

The establishment of the pure type of *Terminalia tomentosa* forest on alluvial land in parts of the sub-Himalayan tract, which has already been alluded to, furnishes a good instance of a combination of factors which favour the reproduction of this species to such an extent that it becomes dominant, forming pure or almost pure forest. The chief factors in question are full overhead light, loose soil, sufficient soil moisture, and absence of dense weed-growth, though the ground may be covered with an open growth of moderately tall grass. The gradual evolution of this type of forest, which is illustrated in Figs. 197–200, is as follows:

The fruits are partly wind-borne and partly water-borne, and the seed germinates on alluvial deposits in the beds and along the banks of streams in a soil consisting of sand, or of fine sand with an admixture of clay forming a rich alluvial loam. Frequently *Acacia Catechu* and *Dalbergia Sissoo* are found coming up along with the *Terminalia*, the latter being mixed with the others either by single trees or, as is more common, by groups. In such a mixture the *Acacia* and *Dalbergia* eventually become outgrown and suppressed by the *Terminalia*, and the latter forms a pure crop or, if there are gaps in the crop, other species may come in; of these the commonest is *Anogeissus latifolia*, while sal also tends to appear where the locality is suitable and the cover is not too dense.

The development of this forest is interesting as showing that *Terminalia tomentosa*, like *Acacia Catechu* and *Dalbergia Sissoo*, is capable of establishing itself on new alluvial ground on which sal is unable to establish itself owing to the fact that the soil moisture in the dry season of the year is insufficient to support it; in other words, *Terminalia tomentosa* is capable of establishing

itself in soil in which sal fails to survive for want of sufficient permanent moisture. On the other hand, a copious rainfall in the year of seeding appears to favour natural reproduction: thus in the Dehra Dun forests in 1910, following a season of abundant rainfall, young seedlings were found in great abundance in the ensuing cold weather.

In connexion with soil moisture it may be mentioned that seedlings of *Terminalia tomentosa*, like those of sal, have been observed to die back in dry localities, forming long thick taproots which enable the young plants eventually to establish themselves.

Excessive grazing is a serious menace to natural reproduction. Allusion has already been made under 'silvicultural characters' to a bushy growth resulting from excessive grazing in the Bhandara district, Central Provinces. In the Gonda district of the United Provinces, where excessive grazing has resulted in a dense undergrowth of *Carissa spinarum* with little or no reproduction of tree species, the plan was adopted a few years ago of cutting the *Carissa* and with the cut plants forming a thorny fence round coupes recently felled, in order to keep out cattle: the exclusion of grazing combined with the admission of light resulted in abundant reproduction of *Terminalia tomentosa*, and provided weed-growth is kept within bounds its establishment is assured.

(In the drier types of forest, fire is undoubtedly injurious to natural reproduction, but in moist types, such as those of Kanara and Malabar, fire-protection tends to oust this and other deciduous species and to replace them by shade-bearing evergreens) Mr. F. A. Leete,[1] writing in 1900 of the results of fire-protection in the sal forests of Kheri and Bahraich in Oudh, observed that fire-protection had not favoured *Terminalia tomentosa* reproduction, but the reverse, and that although saplings which originated before the days of fire-protection were plentiful, seedling reproduction had come to a standstill. Mr. (now Sir Sainthill) Eardley-Wilmot,[2] referring to these observations, noted that the forests in question had passed through three stages, namely:

'First stage. The forest annually burnt, impossible for seed to germinate save in those localities which escaped fires; in consequence the tree represented in perfection in low-lying areas and along the drainage lines and banks of lakes.

'Second stage. The forests protected from fire, the above restriction removed and immediate spread of the species over the ruined sal forest.

'Third stage. Continued protection, recovery of vitality in the sal forest, renewed suitability of the soil for sal reproduction, intolerance and defeat of other species by the triumphant sal forest.'

The observation on the third stage undoubtedly bears out the results of the preliminary experiments in respect of the light requirements of the young plant and its inability to compete with more vigorous vegetation, in this case sal. The explanation of the paucity of *Terminalia* reproduction in this case is no doubt the correct one, namely, that whereas reproduction is favoured by fire-protection, it is prevented by continuous protection, which favours the sal to a greater extent. In such a case the reproduction of *Terminalia* must be looked for only in places unsuitable for the sal, and this is in fact the case,

[1] Ind. Forester, xxvi (1900), p. 239.

[2] *Ibid.*, p. 377

for it is in low-lying badly drained ground, where sal cannot gain a footing, that *Terminalia* chiefly springs up.

The fruits fall for the most part before or during the season of fires, and this fact has been held to be a preventive of reproduction owing to the destruction of the fruit. In the case of severe fires the germinative power of the seed is possibly destroyed, but in the case of light fires it is difficult to believe, in the absence of definite tests, that the hard endocarp is not a sufficient protection to the seed.

In some localities, particularly in the Indian Peninsula, the plants assume a low bushy growth only a few feet high, which they may maintain for several years before they commence to grow up. Haines notes that the ultimate stem is a sympodium, arising not from the apex of one of the shoots but from a bud lower down. The cause of this bushy growth is not always definitely known, but probably it is due to more causes than one. Excessive grazing, and more probably trampling, have already been noted as a cause. Frost certainly produces this growth, for it has been noticed to be prevalent in frosty hollows where the stems are killed back annually. Fire and suppression are other possible causes, while on the analogy of the dying back of sal this abnormal growth may perhaps be due in some cases to want of soil moisture, to stiffness or hardness of the soil, or to some other unfavourable soil factor, such as bad soil-aeration. It has been suggested that rich soil and absence of weeds may be possible causes of this form of growth ; if this be the case these factors certainly do not always cause it. Mr. P. M. Lushington mentions that the pruning of all but the strongest shoot may result in a leader being formed.

Artificial reproduction. Direct sowings, as well as transplanting from the nursery during the first rains, before the taproot has reached any great length, prove quite successful. In order to ensure regular weeding at small cost sowing in lines is preferable to other forms of sowing ; in order to allow for indifferent germination the fruits should be sown fairly close together, at intervals of about 6 in., superfluous plants being afterwards transplanted to fill gaps in the lines. Line sowings with field crops have proved successful on an experimental scale, the lines being kept clear of crops to a width of about 2 ft. Pit sowings to fill up blanks have proved successful in Bombay. Sowing should be carried out before the early rains, the soil being worked up and the fruits lightly covered. As a rule 1 lb. of fruits will suffice for 100–120 ft. of line. In the nursery the fruits should be sown not long after they ripen, about March–April, and if the beds are regularly watered and weeded the seedlings should be ready for transplanting early in the rainy season. In Bombay the fruits are sown on a layer of leaves and grass in order to raise them from the ground and prevent them from rotting : the seed germinates readily after a good fall of rain, and the seedlings are easy to lift without damage to the root if the sowing is done on leaves.[1]

Mr. R. Bourne informs me that in Malabar he has obtained the best results in germination by sowing the seeds in seed-beds divided into squares surrounded by small mud walls, so that when the beds are flooded the water stands in them for some time.

[1] R. S. Pearson in Ind. Forester, xxxi (1905), p. 170.

Owing to the light requirements of the young plants, sowing and planting under cover should be avoided, such work being confined to open places or gaps of some extent. Plantations are apt to be damaged by deer and pigs.

Silvicultural treatment. The correct treatment of this tree must be based on its light-demanding character during all stages of its existence. Actually its treatment is as a rule that of an accessory species to more valuable trees such as teak or sal, or as a component of a mixed crop in which it is not of outstanding importance. Under existing working plans it is worked along with other species usually under some form of selection fellings or under coppice-with-standards. For the rearing of silkworms it is regularly pollarded. It is quite suitable for working as even-aged high forest with natural or artificial reproduction.

Rate of growth. (1) *High forest.* The annual rings are not always clearly distinguishable, though the rate of growth in several working plans is based on the results of ring-countings; the figures deduced in this way may be taken as only approximately correct. The results of various sample plot measurements are available, and these may be taken to be more accurate than the figures based on ring-countings, though here also there is an element of uncertainty in the fact that the time required for a seedling to establish itself under different conditions is not known.

United Provinces. The statement below gives a summary of the results of sample plot girth measurements in natural forest up to 1917, the measurements in all sample plots being combined for separate localities or forest divisions. These sample plots are situated in sal forest.

Terminalia tomentosa: girth increment in high forest sample plots, United Provinces.

	Corresponding girth.											
Age.	Dehra Dun. (260 trees)		S. Kheri. (67 trees)		N. Kheri. (30 trees)		Gonda. (64 trees)		Pilibhit. (21 trees)		Bahraich. (30 trees)	
years.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
10	..		..		..		..		..		0	5
20	..		0	5	0	7	0	4	..		0	10
30	0	11	0	10	1	1	0	7	..		1	5
40	1	4	1	2	1	8	0	11	2	0	2	0
50	1	10	1	6	2	2	1	4	2	6	2	7
60	2	3	1	11	2	8	1	8	2	11	..	
70	2	9	2	4	3	2	2	0	3	3	..	
80	3	4	2	10	3	7	2	4	3	7	..	
90	3	11	3	4	4	0	2	9	3	11	..	
100	4	6	3	10	4	4	3	1	4	2	..	
110	5	2	4	5	4	8	3	6	..		..	
120	5	9	5	1	4	11	3	10	..		..	
130	..		..		5	2	4	3	..		..	
140	..		..		5	4	4	9	..		..	
150	..		..		5	6	5	4	..		..	
160	..		..		5	8	5	11	..		..	
170	..		..		5	10	..		..		..	
180	..		..		5	11	..		..		..	

Note.—Measurements taken over bark at $4\frac{1}{2}$ ft. from ground-level: no addition made for time required for seedling to establish itself.

Bihar and Orissa. The following are the results of measurements in two sample plots in the Singhbhum forest division, (1) in Tirilposi block, (2) on the Samta-Hendakuli old road :

Terminalia tomentosa : girth increment in high forest sample plots, Singhbhum division.

Girth class.	No. of trees under observation.		No. of years under observation.		Mean annual girth increment for period.	
	(1)	(2)	(1)	(2)	(1)	(2)
ft.					in.	in.
2–3	1	..	18	27	0·47	..
3–4	6	18			0·51	0·30
4–5	..	..			..	..
5–6	..	3			..	0·33
6–7	..	1			..	0·37

A tree raised from seed sown in 1901 by Mr. Haines in the forest garden at Chaibassa attained in sixteen years a height of 33 ft. and a girth of 2 ft. 3½ in.

Central Provinces. Ring-countings in the case of a few felled trees in the South Chanda forest division gave the following results : [1]

Terminalia tomentosa : girth increment, South Chanda, Central Provinces.

Girth at 4½ ft. from ground-level.	Age.	Mean annual girth increment.
in.	years.	in.
6	8½	0·71
12	17	0·70
18	25½	0·71
24	47	0·51
30	76	0·40

Note.—No addition made for time required for establishment of seedling.

The following results of sample plot measurements extending over a period of eight years in respect of 39 trees in the Baihar and Raigarh ranges of the Balaghat division show a very slow rate of growth : [2]

Terminalia tomentosa : girth increment in high forest sample plots, Balaghat.

Age.	Mean girth.		Age.	Mean girth.		Age.	Mean girth.	
years.	ft.	in.	years.	ft.	in.	years.	ft.	in.
20	0	3½	70	1	5¼	120	2	6¾
30	0	6	80	1	8	130	2	9¼
40	0	9	90	1	10¾	140	3	0
50	1	0	100	2	1¼			
60	1	2¾	110	2	4			

Note.—No addition made for time required for establishment of seedling.

[1] Working Plan for the Dhaba, Ghot, and Markhanda Ranges and Elchil Forest, South Chanda, J. Donald, 1913.

[2] Statistics compiled in the Silviculturist's office, 1916–17 ; Ind. For. Rec., vol. vi, pt. v.

Bombay. The following table has been compiled from measurements based on ring-countings and recorded in high forest working plans in Bombay:

Terminalia tomentosa: diameter increment in high forest, Bombay Presidency.

Age.	North Kanara district.							Surat district.
	Supa fuel reserves.[1] (1906)	Ankola high forest, Blocks xxiv and xxv.[2] (1908)	Kalinaddi slopes, Block xxvi.[3] (1909)	Sopinhosalli high forest, Block xxvii.[3] (1910)	Ankola-Kumta coast.[3] (1911)	Sirsi town forests.[3] (1913)	Yekambi-Sonda high forest, Block xxviii.[3] (1914)	North Dangs forests.[4] (1912)
years.	in.	in.	in.	in.	in.	in.	in.	in.
10	2·21	2·18	2·4	1·7	1·6	1·1	1·0	2·5
20	4·20	4·00	5·7	3·7	4·0	2·4	2·6	7·3
30	6·27	5·76	8·4	5·2	6·4	3·7	4·6	10·6
40	8·12	7·46	9·9	6·8	8·6	5·0	6·6	13·2
50	10·06	9·05	12·2	8·4	10·3	6·2	8·8	16·2
60	11·50	10·55	14·2	10·0	11·8	7·4	10·7	20·2
70	..	11·73	15·9	11·6	13·1	8·7	12·5	22·2
80	..	12·80	17·6	13·1	14·3	10·1	14·3	24·5
90	..	14·13	18·9	14·5	..	11·5	16·0	25·5
100	..	15·51	20·4	15·8	..	13·0	17·6	..
110	..	16·82	21·9	17·1	..	14·4	19·2	..
120	..	18·10	23·2	18·5	..	15·6	20·6	..
130	..	19·21	24·4	19·9	..	16·6	21·8	..
140	..	20·75	25·5	21·3	..	17·6	22·8	..
150	..	21·96	26·5	22·7	..	18·0	23·6	..
160	..	23·10	27·3	24·0	..	..	24·4	..
170	..	..	..	..	..	..	25·4	..

Note.—Measurements do not include bark. Thickness of bark is given as 1·3 in. in the North Dangs forests, and 1·6 in. in the Sopinhosalli and Yekambi-Sonda forests.

[1] Measurements by D. A. Thomson.
[2] Measurements by R. S. Pearson.
[3] Measurements by P. E. Aitchison.
[4] Measurements by G. E. Marjoribanks.

Madras. Ring-countings in the Begur forest (25 trees) and Chedleth range forests (77 trees), North Malabar, gave the following results:

Terminalia tomentosa: results of ring-countings, North Malabar, Madras.

Diameter.	Corresponding girth.	Mean age.	
		Begur.	Chedleth range.
in.	in.	years.	years.
6	19	28	26
12	38	58	48
18	57	85	72
24	75	117	100

(2) *Coppice. United Provinces.* Measurements by Mr. C. M. McCrie in 1910 in sal coppice coupes at Ramgarh in the Gorakhpur district gave the following results for *Terminalia tomentosa* as compared with sal (*Shorea robusta*):

Terminalia tomentosa : growth of coppice at Ramgarh, Gorakhpur, United Provinces.

	Mean height.		Mean girth.	
Age.	*Teminalia tomentosa.*	Sal.	*Terminalia tomentosa.*	Sal.
years.	ft.	ft.	in.	in.
2	4·5	3·0	1·3	—
4	9·0	7·0	3·0	2·0
6	12·3	10·3	4·5	2·9
8	15·0	13·0	5·7	3·8
10	17·0	15·3	7·3	4·8

The following measurements made by me in 1911 in young coppice coupes in the Tikri forest, Gonda, show the comparative growth of *Terminalia tomentosa* and sal :

Terminalia tomentosa : growth of young coppice in the Tikri forest, Gonda, United Provinces.

	Mean height.		Average No. of shoots per stool.	
Age.	*Terminalia tomentosa.*	Sal.	*Terminalia tomentosa.*	Sal.
years.	ft.	ft.	in.	in.
1	8·2	4·7	4·7	2·2
2	11·2	10·0	2·9	1·7
2	6·3	7·6	4·7	1·8

Bihar and Orissa. Measurements in coppice coupes of various ages in the Saitba block, Kolhan, Chota Nagpur, in a somewhat dry type of forest on hilly ground with stony soil, gave the following results :

Terminalia tomentosa : growth of coppice in the Saitba block, Kolhan, Chota Nagpur.

	Mean height.		Mean girth.	
Age.	*Terminalia tomentosa.*	Sal.	*Terminalia tomentosa.*	Sal.
years.	ft.	ft.	in.	in.
2	5·5	9·0	1·5	4·0
4	10·5	16·0	3·2	6·5
6	14·5	20·0	4·8	8·6
8	17·8	22·5	6·5	10·3
10	20·4	24·5	8·3	11·5
12	22·7	26·5	10·0	12·6
14	24·5	28·5	11·6	13·6

Bombay. The following coppice measurements are recorded in the working plan for the Karwar fuel reserves, West Kanara forest division : [1]

Terminalia tomentosa : growth of coppice in the Karwar fuel reserves, West Kanara, Bombay.

Age.	Girth.	Age.	Girth.
years.	in.	years.	in.
4	6·75	11	11·16
5	8·46	12	11·31
6	8·55	13	11·69
7	8·71	15	12·75
8	9·26	18	17·0
9	10·55		

[1] Working Plan for the Karwar Fuel Reserves, West Kanara, Bombay, D. A. Thomson, 1904.

4. Terminalia Arjuna, Bedd. Syn. *T. glabra,* W. and A.; *Pentaptera Arjuna,* Roxb. Vern. *Arjún, arjuna, kahua, koha,* Hind.; *Savimadat,* Mar.; *Holematti,* Kan.; *Kula maruthu,* Tam.; *Thella maddi,* Tel. (Fig. 204.)

A large handsome tree, evergreen or nearly so, with trunk often buttressed, a large crown and drooping branchlets. Bark smooth, exfoliating in thin irregular sheets, green when newly exposed, turning light grey, pink inside; young bark with chlorophyll. The tree resembles *T. tomentosa* except for its smooth bark, the narrower wings to the fruits, and the fact that it is characteristic of the banks of streams. It sometimes attains an enormous girth. Mr. J. C. McDonnell [1] records two trees 26 ft. and 32 ft. in girth at 5 ft. from ground-level at the village of Manapur in Jammu.

The wood is brown, very hard, used for building, agricultural implements, carts, and boats. The bark is used for tanning, and is much collected for the purpose in Central India. A special blazing instrument is used which strips off flakes of cortex without penetrating to and damaging the cambium, and within two years the stripped patches are covered with a thick new growth of cortex slightly lighter in colour than the original bark: if the cambium is injured the wood blackens and no regrowth of cortex takes place.

Distribution and habitat. *Terminalia Arjuna* is common throughout the greater part of the Indian Peninsula along rivers, streams, ravines, and dry watercourses, reaching a large size on fertile alluvial loam. It extends northward to the sub-Himalayan tract, where it is locally distributed along the banks of streams. It is common in Chota Nagpur, Central India, the Central Provinces, and parts of the Bombay and Madras Presidencies, extending south to Ceylon. It is often planted for shade or ornament along roadsides and in avenues. In some localities it has escaped from cultivation along streams, and is doubtfully indigenous. It is found naturally in regions where the absolute maximum shade temperature varies from 100° to 118° F., the absolute minimum from 30° to 60° F., and the normal rainfall from 30 to 70 in.; as, however, its occurrence depends largely on the moisture supplied by streams, its distribution is not governed by climatic considerations alone.

Leaf-shedding, flowering, and fruiting. The tree is evergreen or nearly so, the new foliage appearing early in the hot season. The panicled spikes of small white flowers appear from April to July, and the fruits ripen the following February to May. The fruits (Fig. 202, *a*) are 1–2 in. long, with a hard bony axis and five to seven wings 0·25–0·5 in. broad; about 80–110 weigh 1 lb. As in *T. tomentosa*, the germinative power of the seed is often indifferent. The tree flowers and fruits at an early age: a tree six years old flowered and fruited abundantly at Dehra Dun in 1918.

Germination (Fig. 202, *b–f*). Epigeous. The hard endocarp of the fruit opens slightly and the radicle emerges. The hypocotyl elongates by arching, and the large foliaceous cotyledons, which are convolute in the seed, extricate themselves and unroll. The hypocotyl straightens and still farther elongates, carrying the cotyledons above ground; at the same time the young shoot emerges from between the two cotyledonary petioles.

[1] Ind. Forester, xxix (1903), p. 152.

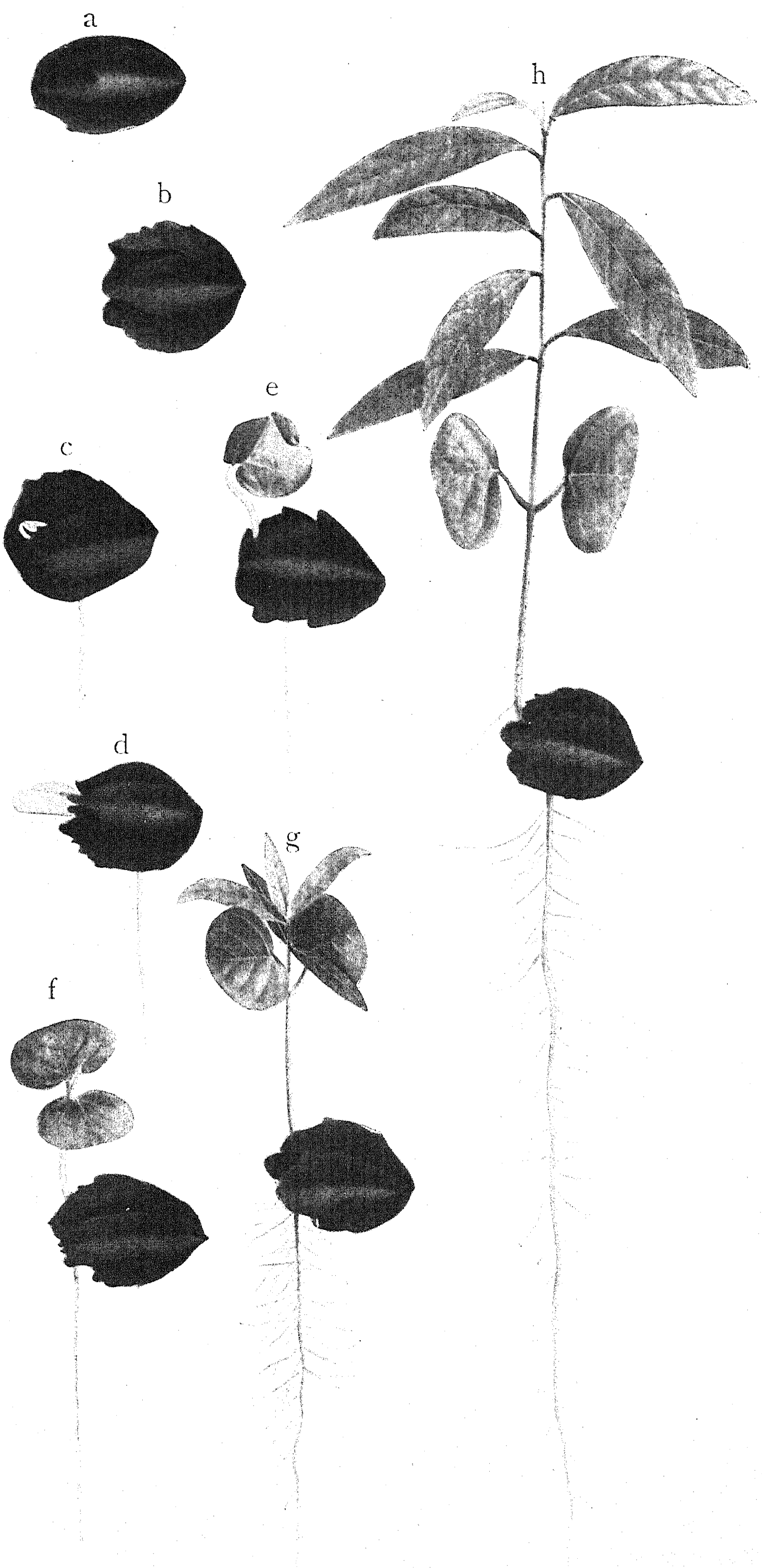

FIG. 202. *Terminalia Arjuna*—SEEDLING × $\frac{3}{8}$

a—Fruit b - f—Germination stages g, h—Development of seedling to end of first season

THE SEEDLING (Fig. 202).

Roots: primary root long, terete, tapering, wiry: lateral roots numerous, fibrous, distributed down main root. *Hypocotyl* distinct from root, 2·2–3 in. long, terete or slightly compressed, tapering slightly upwards, tomentose. *Cotyledons*: petiole 0·3–0·6 in. long, flattened above, tomentose: lamina 0·7–0·9 in. by 1·4–2·2 in., foliaceous, somewhat fleshy, reniform, much broader than long, apex broadly truncate, base decurrent, entire, green, with three conspicuous and two minor veins from the base. *Stem* erect, terete, pubescent; first internode, above the cotyledons, 1·8–2·2 in., subsequent internodes 0·2–1 in. long. *Leaves* simple, alternate, or first pair sub-opposite, exstipulate. Petiole 0·2–0·3 in. long, flattened above, pubescent. Lamina 2·4–4 in. long, elliptical lanceolate, apex and base acute, widely serrulate, sparsely pubescent, or glabrous on the upper surface, venation sub-arcuate, lateral veins 8–12 pairs.

The young seedling of this species is easily distinguished from those of *T. tomentosa* and *T. Chebula* by the length of the hypocotyl and cotyledonary petioles (see p. 519).

The growth of the seedling during the first season is somewhat faster than in the case of *T. tomentosa*, a height of about 5–12 in. being ordinarily attained under natural conditions, and a height of 1 ft. to 1 ft. 9 in. in the case of nursery-raised plants. A fairly long taproot is developed early and may attain a length of as much as 1 ft. within two months of germination. As in the case of *T. tomentosa* and *T. myriocarpa*, the young plant during the first few years tends to assume a straggling or branching formation, sacrificing height-growth to the production of long side branches which bend over towards the ground. This does not always occur, however, and rapid height-growth may take place from the commencement; thus young tended plants at Dehra Dun have attained a height of 6–10 ft., with a basal girth of 5–8 in., in three years. In Berar seedlings have reached a height of 1½ ft. in two years, and at Nagpur they have attained 3 ft. in 2½ years. Growth is stimulated by regular watering and loosening of the soil.

The seedlings are somewhat sensitive to frost, and are decidedly sensitive to drought, both in the germinating stages and subsequently. They grow well in full sunlight provided the ground is moist; they also stand moderate shade, but not dense overhead shade. In northern India the season's growth ceases in November–December and new growth commences about March.

SILVICULTURAL CHARACTERS. The tree is capable of standing more shade than *T. tomentosa*. It has a more or less superficial root-system, and relies for its moisture chiefly on the streams whose banks it frequents. It is somewhat tender to frost as well as to drought. Mr. C. M. McCrie [1] notes regarding the abnormal drought of 1899 and 1900 that many trees along the banks of the streams in the Nagpur district died owing to the lowering of the subsoil water-level. The tree produces root-suckers and pollards well. Experiments in Bombay have shown that it coppices well up to a girth of about 2½ ft., after which the coppicing power is indifferent.

NATURAL REPRODUCTION. Under natural conditions germination takes place early in the rainy season, and may actually commence with the early showers before the monsoon proper. Numerous experiments at Dehra Dun,

[1] Ind. Forester, xxvi (1900), p 338.

including plots of ground kept moist by percolation in order to imitate natural conditions, showed that the seed does not germinate readily if exposed to the sun, and if germination begins the radicle is very liable to dry up. If the fruits become partially buried by rain or otherwise germination is much more successful, while the success is greater on bare soil with a considerable amount of moisture, provided the fruits are buried : these conditions ordinarily obtain on alluvial ground along streams. A certain degree of shade, particularly from the side, assists the establishment of the seedling, but heavy shade is inimical. In the forest seedlings are often to be found in large quantities where the fruits have been accumulated by the action of streams in loose alluvial soil and conditions for germination have been favourable.

ARTIFICIAL REPRODUCTION. The plants bear transplanting well during the first rainy season before the taproot becomes too long. The fruits should be sown in the nursery about April–May, covered lightly, and watered regularly. Irrigated weeded line sowings have been found successful.

RATE OF GROWTH. Few detailed statistics are available regarding the rate of growth, but young trees planted at Dehra Dun and well watered have grown fairly rapidly. A cross-section from the United Provinces 2 ft. 8½ in. in girth, including bark, in the silvicultural museum at Dehra Dun showed 43 rings, giving a mean annual girth increment of 0·75 in. Trees raised from seed sown in 1901 by Mr. Haines in the forest garden at Chaibassa, Chota Nagpur, attained the following dimensions in sixteen years :

(1) Height 40 ft., girth 2 ft. 11 in.
(2) Height 37 ft., girth 2 ft. 8 in.
(3) Height 37 ft., girth 1 ft. 8½ in.

Measurements in coppice coupes in Bombay showed that a height of 12 ft. and a girth of 10 in. may be expected in six to seven years.

5. **Terminalia myriocarpa,** Heurck and Muell. Arg. Vern. *Panisaj*, Nep. ; *Hollock*, *jhalna*, Ass.

A very large evergreen tree with pendulous branches. Bark greyish brown, rough, exfoliating in vertical flakes. Wood dark brown, hard, used for house-building, canoes, cheap furniture, and other purposes. The tree attains very large dimensions. Mr. Jacob [1] records one tree in the Raidak valley over 30 ft. in girth, and two trees close together in the Chirrang valley roughly 36 and 27 ft. in girth. Babu R. N. De [2] records a tree 46 ft. 4 in. in girth round buttresses in the Lakhimpur district, Assam.

DISTRIBUTION AND HABITAT. Eastern Himalaya from Nepal eastwards, in valleys and lower hills up to 5,000 ft., Assam, hills of Upper Burma. It is very plentiful in some localities, often coming up in gregarious patches on newly exposed ground, forming pure even-aged groups underneath which evergreen species appear. Mr. Jacob notes that it is very common in Bhutan up to 3,000 ft. and is found up to 4,000 ft. Mr. Milroy [3] reports that in the Abor country it is the predominant tree on the lower hills, where trees of 12 and 14 ft. girth are common, and still larger ones up to 18 and 20 ft. are not scarce ; he adds that although the trees are apt to be short in the bole

[1] Report on the Forests of Bhutan, 1912. [2] Ind. Forester, xliv (1918), p. 517.
[3] Report on the Forest Resources of the Abor Country, 1912.

FIG. 203. *Terminalia myriocarpa*—SEEDLING × ½

a—Fruit b - d—Germination stages e - i—Development of seedling to end of first season

and much branched a great quantity of clean timber could be extracted from them.

Terminalia myriocarpa is essentially a tree of moist situations and rich soil, and in Assam is often found associated with *Bischoffia javanica*. In its natural habitat the absolute maximum shade temperature varies from 90° to 102° F., the absolute minimum from 33° to 45° F., and the normal rainfall from 80 to 200 in. or possibly more.

FLOWERING AND FRUITING. The panicles of small pink flowers appear in October–November and the fruits ripen from March to June. The fruits (Fig. 203, *a*) are small and light, 0·1–0·15 in. long, light yellowish brown, with a pair of lateral membranous wings, the whole 0·4–0·5 in. in width. About 4,000 to 4,500 weigh 1 oz. The germinative power of the seed is fairly good, tests at Dehra Dun showing a fertility of 63 per cent., which for a small light seed is not unsatisfactory. Seed-year records show that the tree seeds well as a rule every year. The trees are a very handsome sight when covered with masses of pink blossom or yellow fruits.

GERMINATION (Fig. 203, *b–d*). Epigeous. The thin radicle emerges from one end of the winged fruit and the cotyledons from the other ; the hypocotyl quickly elongates, carrying above ground the cotyledons, which expand in the meantime, and the young shoot emerges from between them.

THE SEEDLING (Fig. 203).

Roots : primary root moderately long, terete, tapering, wiry : lateral roots numerous, fine, fibrous, distributed down main root. *Hypocotyl* distinct from root, 0·5–0·8 in. long, thin, terete, cylindrical, tomentose. *Cotyledons* : petiole 0·1–0·15 in. long, flattened above, pubescent : lamina 0·1–0·2 in. by 0·15–0·3 in., foliaceous, reniform or sub-orbicular, broader than long, apex truncate or retuse, base tapering, entire, glabrous or minutely pubescent. *Stem* erect, terete, green or red, rusty tomentose ; internodes 0·2–0·7 in. long. *Leaves*, first pair opposite, small, subsequent leaves larger than first pair, alternate, exstipulate. First pair with petiole 0·1 in. long or less, tomentose, lamina 0·4–0·5 in. by 0·15–0·2 in., elliptical lanceolate, apex and base acute, entire or obscurely serrate, glabrous or sparsely pubescent above, sparsely pubescent beneath. Subsequent leaves with petiole 0·1–0·3 in. long, tomentose, lamina 0·1–2·8 in. by 0·4–1 in., elliptical lanceolate, acuminate, base acute, serrate, pubescent, venation arcuate, lateral veins 6–10 pairs, nearly reaching the margin ; later leaves of the first season with glands at the base. The serrate leaves of the seedling are interesting ; the adult leaves of this species, and of the whole order, are entire.

In its early stages the seedling is minute, and is apt to be washed away by rain before it gains a footing. It develops rapidly, however, and attains a height of about 4–8 in. or more by the end of the first season. As in the case of *T. tomentosa* and *T. Arjuna*, the young plant has a tendency to produce long straggling branches in place of a definite leader, but in spite of this its height-growth after the first season is rapid. Sixteen plants grown at Dehra Dun had a height of 4 ft. 8 in. to 7 ft. 3 in. by the end of the second season, and 10 to 15 ft. by the end of the third season.

SILVICULTURAL CHARACTERS. The tree bears a fair amount of shade and is exacting as regards moisture. It is not known to produce root-suckers.

NATURAL REPRODUCTION. The ideal conditions for successful reproduction are a loose porous soil free from weeds, in order to enable the small light

fruit to reach the soil and the germinating seedling to establish itself quickly, and a fair amount of soil moisture. The light fruits tend to be washed into heaps and the minute seedlings are also liable to be washed away, considerable mortality resulting. The young seedlings are apt to dry up if exposed to the sun, and benefit by a certain amount of shade; they are also apt to die off in quantity on stiff water-logged soil, and good drainage appears to be necessary for their establishment. The young crop often tends to come up gregariously, where conditions are favourable, on newly exposed ground or fresh alluvium.

Artificial reproduction. Direct sowings are unsuitable, as the small light fruits are liable to be washed away. Experiments at Dehra Dun showed that the best results are attained in fine porous sandy soil in boxes or in well-raised beds protected from sun and heavy rain; watering should be frequent but light. Germination ordinarily starts in two or three weeks and may continue for about three months. The plants transplant well during the first rainy season when 3 to 4 in. high.

6. Terminalia Catappa, Linn. Syn. *T. procera,* Roxb. Indian almond. Vern. *Badam,* Beng. Known in the Andamans as 'white bombway', a corruption of the Burmese *banbwè* (*Careya arborea*).

A large handsome deciduous tree with whorled branches and large glabrous leaves which turn red before falling in the hot season. Bark smooth, grey, stem often buttressed. The tree is a native of the Andamans and adjacent islands and of the Malay Peninsula, in coast forests. It is extensively planted in tropical India and in Burma, particularly round monasteries, both for ornament and for the sake of its fruits, the kernels of which are eaten.

In the Andamans it is common in the littoral forests on raised beaches and deposits of sea-sand above high tide, associated with *Calophyllum Inophyllum, Afzelia bijuga, Thespesia populnea, Heritiera littoralis, Erythrina indica, Sterculia* spp., *Pongamia glabra, Odina Wodier, Hibiscus tiliaceus,* and *Pandanus tectorius.* It also extends into the padauk forests, where it is confined to sandy soil as a rule not far from the sea, or to diluvial deposits formed of detritus brought down by streams in flood.

The whitish flowers, in axillary spikes, appear from February to May, and according to Bourdillon again in October–November (Travancore). The fruits ripen in June–July (also January, Bourdillon). The fruit is a yellowish ellipsoidal drupe, somewhat compressed, 1·5–2 in. long, with a porous fibrous to fleshy pericarp and a hard endocarp enclosing the edible seed. The fruit is adapted for dissemination by water, the thick husk of porous tissue rendering it buoyant. The tree is easily raised from seed, the fruits being sown in the nursery about July and the seedlings transplanted during the following rainy season. The tree grows best in a moist tropical climate.

7. Terminalia paniculata, Roth. Vern. *Kindal, kinjal,* Mar.; *Hulve, honal, bili-matti,* Kan.; *Pulavâi, venmarudu, pumarudu,* Tam.; *Nimiri, pulamaddi,* Tel.

A large to very large deciduous tree. Bark 0·4–0·6 in. thick, dark brown, rough, with numerous shallow longitudinal and transverse fissures. The lower part of the bole is often much fluted. Heartwood light brown, very hard; wood used chiefly for planking, agricultural implements, and canoes, but not

quite so much in demand as that of *T. tomentosa*. The bark contains much tannin.

The tree reaches considerable dimensions. Mr. H. Tireman records one 13 ft. 3 in. in girth measured in the Coorg forests: large trees, however, are usually unsound inside. It attains a height of 100 ft. under favourable conditions.

Distribution and habitat. The tree is found in the western regions of the Indian Peninsula from Bombay southwards, and in southern India. In Bombay it is one of the commonest trees of the North Kanara mixed deciduous forests, its most important associates being teak, *Dalbergia latifolia*, *Pterocarpus Marsupium*, *Terminalia tomentosa*, *Lagerstroemia lanceolata*, and *Xylia xylocarpa*. It is rare on the Deccan trap and absent from the Dangs and Satpuras. It extends southwards through South Canara and Malabar to Travancore, and occurs in the Nilgiris, Anamalais, and other hill ranges of southern India. In Coorg it is most plentiful and attains its largest dimensions in the deciduous forests of the *ghats*; it is also found throughout the eastern forests, but here it reaches smaller dimensions. Throughout its region it is often the most plentiful species of the mixed forests. Bourdillon says it is probably the commonest tree in Travancore, often forming 50–60 per cent. of the trees in the deciduous forests up to 2,000 ft. elevation. It is also the commonest timber tree of the Nilambur valley in Malabar and of some of the Kanara forests.

The tree is most frequently found in valleys and on lower slopes, preferring fairly moist situations. It requires a well-drained soil, and is not found on water-logged ground, thus differing from *T. tomentosa*. In the Western Ghats it grows equally well on the laterite soils at the foot of the *ghats* and on the decomposed crystalline rocks of the slopes.

In its natural habitat the absolute maximum shade temperature varies from 95° to 102° F., the absolute minimum from 55° to 65° F., and the normal rainfall from 40 to 180 in. or more.

Flowering and fruiting. The flowering season appears to vary. Brandis gives it as August to December, Talbot (Bombay) as August to September, and Bourdillon (Travancore) as July to December, one flowering succeeding another. Mr. H. Tireman informs me that in Coorg he has observed it in flower in April–May. The flowers are small and white in rusty-pubescent panicled spikes.

The fruits, which ripen from December to May, are brick-red, 0·25–0·5 in. long, with one large wing about 0·5–0·75 in. broad and two smaller wings; about 100–120 fruits weigh 1 oz.

Silvicultural characters. The tree stands rather more shade than *T. tomentosa*, saplings and poles being found coming up in small gaps; it will not, however, stand heavy shade, and may be regarded as a light-demander rather than a shade-bearer. Frost is unknown within its region, and prolonged drought seldom if ever occurs. The tree coppices well up to a moderate size.

Natural reproduction. The natural reproduction of this tree is as a rule plentiful, though the conditions influencing it require further study. In many places the moist deciduous forests of Kanara are gradually changing towards the evergreen type as a result of fire-protection, and the natural

reproduction of this and other deciduous trees is reported to be suffering in consequence, though it is plentiful near cultivation and along the sides of roads where heavy weed-growth is kept down. Mr. Tireman notes that in the Coorg *ghats* it probably owes its existence to fires, as the deciduous forest is almost certainly due to the *kumri* cultivation which has killed all the evergreen trees which must formerly have covered the locality. This would further indicate that newly exposed ground, such as that obtained by shifting cultivation, is a favourable factor, as it is in the case of light winged seeds and fruits in general.

RATE OF GROWTH. The following table shows the rate of growth in diameter, based on the results of ring-countings recorded in working plans of the North Kanara district, Bombay:

Terminalia paniculata: growth in diameter in high forests of the North Kanara district, Bombay.

Age.	Supa fuel reserves.[1] (1906)	Ankola high forest, Blocks xxiv and xxv.[2] (1908)	Kalinaddi slopes, Block xxvi.[3] (1909)	Sopinhosalli high forest, Block xxvii.[3] (1910)	Ankola-Kumta coast.[3] (1911)	Sirsi town forests.[3] (1913)	Yekambi-Sonda high forest, Block xxvii[3] (1914)
years.	in.	in.	in.	in.	in.	in.	in.
10	2·1	2·1	2·2	1·2	1·8	1·0	1·2
20	4·2	4·1	4·4	2·8	4·0	2·4	2·8
30	6·6	5·9	6·6	4·4	6·3	3·8	4·8
40	9·2	7·7	8·8	6·4	8·5	5·4	7·0
50	11·8	9·5	11·0	8·5	10·8	7·2	9·4
60	13·3	11·2	13·2	10·5	13·0	9·0	11·5
70	..	12·9	15·2	12·6	15·2	11·1	13·5
80	..	14·6	17·1	14·6	17·4	13·3	15·4
90	..	16·2	19·0	16·7	..	15·1	17·0
100	..	17·8	20·7	18·8	..	16·6	18·5
110	..	19·4	22·5	20·9	..	17·7	20·0
120	..	20·6	24·1	23·0	..	..	21·5
130	..	22·0	25·4	..	..	..	23·1
140	..	23·3	26·4	..	..	..	24·7
150	..	24·2	27·2	..	..	..	26·4
160	..	24·9	27·6	..	..	..	..
170	..	25·6	..	..	..	..	..

Note.—Diameter excludes bark. Average bark thickness 0·4 in. in Ankola high forest and Kalinaddi slopes, 0·6 in. in Sopinhosalli high forest.

[1] Measurements by D. A. Thomson.
[2] Measurements by R. S. Pearson.
[3] Measurements by P. E. Aitchison.

As regards coppice, the following measurements by Mr. H. A. Gass in the Kadike block of the South Canara district, Madras, were recorded in 1898–9:

Terminalia paniculata: coppice measurements, South Canara.

Age.	Girth.	Height.	No. of shoots per stool.
years.	in.	ft.	
2	8	15	2
	4	18	4
	7	15	6
3	10½	15	
	9½	12	
	9½	18	
	14	20	8
	12	18	

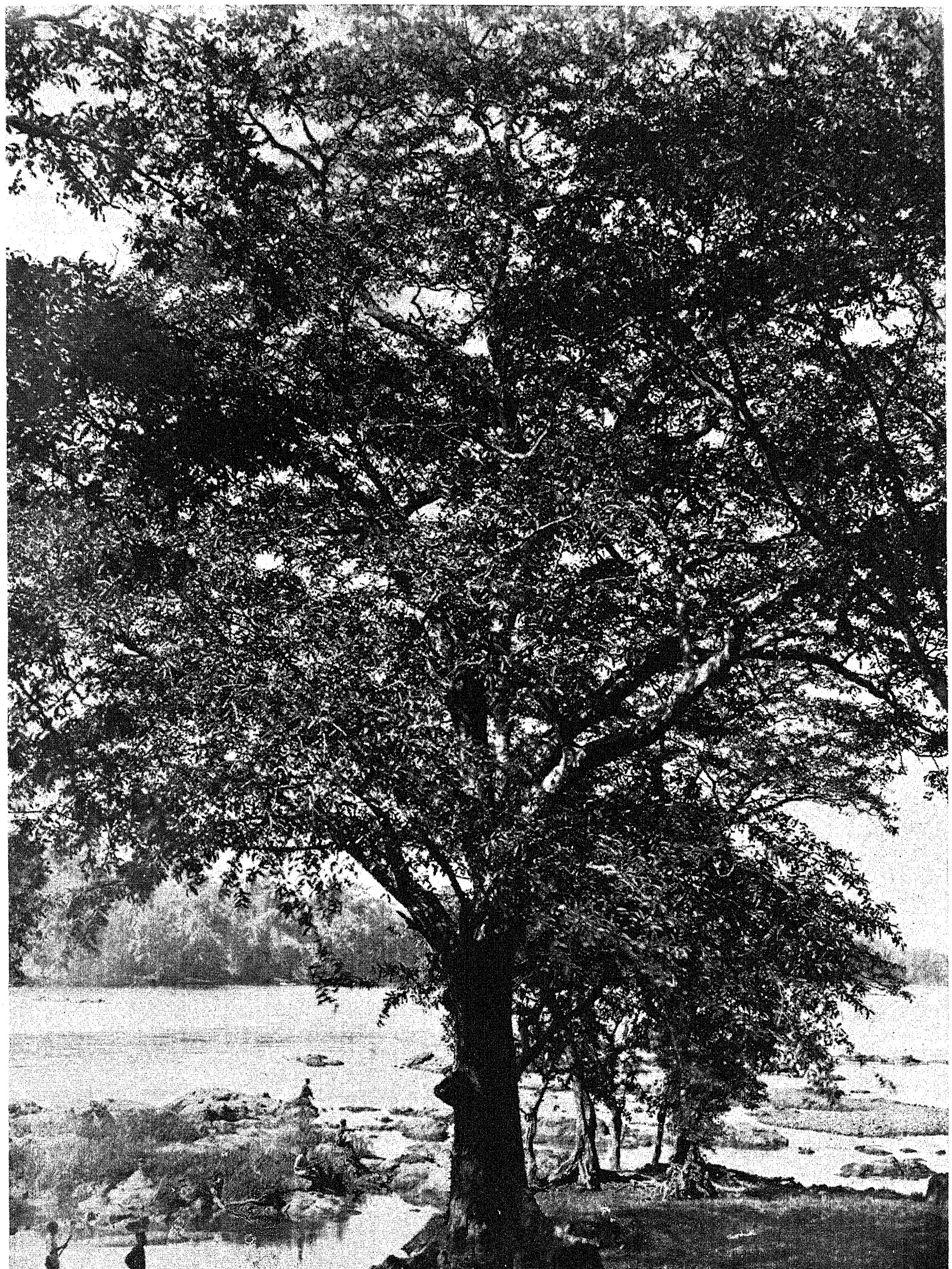

FIG. 204. *Terminalia Arjuna*, Bombay.

FIG. 205. *Anogeissus latifolia*, Dehra Dun, United Provinces.

8. **Terminalia bialata**, Steudel. White chuglam (Andamans). Vern. *Lein*, Burm.; *Chugalam*, And.

A large deciduous tree of Burma and the Andamans, reaching a height of 100 ft. In Burma it occurs in the upper mixed deciduous forests along with teak and its associates, and probably also in the lower mixed forests. In the Andamans it is one of the chief species in the semi-deciduous forests associated with *Pterocarpus dalbergioides* (padauk), *Lagerstroemia hypoleuca*, *Bombax insigne*, *Sterculia* spp., *Albizzia Lebbek*, and others. It also occurs sometimes in the evergreen dipterocarp forest. It flowers in the rainy season (Brandis) and the fruits ripen in the cold season (Kurz); ripe fruits have been received from Burma in February. Mr. C. G. Rogers [1] says that numbers of germinating seeds were seen in the Andaman forests in the month of May, and that the large proportion of this species, including saplings and poles, in the standing crop points to its being better able to reproduce itself naturally than the other trees associated with padauk. The wood of this tree is strong, elastic, straight grained, and of good quality, and it is likely to become an important timber when better known.

Another tree known in Burma as *lein* is common on the plains of Pegu, where it is of comparatively small size with a bushy form of growth. This is probably *T. pyrifolia*, Kurz, which, according to Brandis, merits careful study in the forest, as to whether it is really a distinct species; its size and mode of growth are certainly different from that of the larger and cleaner-stemmed *T. bialata*.

9. **Terminalia Oliveri**, Brandis. Vern. *Than*, Burm.

A moderate-sized deciduous tree with smooth greenish grey bark and a somewhat irregularly shaped and often channelled stem. It attains a height of 40–50 ft. and a girth of 4–5 ft., but on poor ground it is stunted. The leaves are only 1·5–3 in. long, and turn red before falling in the hot season. The fruit is five-winged like that of *T. tomentosa*, but much smaller. The wood is a good fuel and the bark is illicitly used to adulterate cutch. This tree is very common in the dry zone of Upper Burma in tracts where the rainfall varies from 22 to 40 in. and the soil is often poor and shallow. It extends from the Magwe and Yamethin districts in the south to about $23\frac{1}{2}°$ N. lat. in the Ruby Mines district in the north. It is one of the most characteristic trees of the dry open forests associated with *Acacia Catechu*, *A. leucophloea*, *Tectona Hamiltoniana*, *Diospyros burmanica*, *Terminalia tomentosa*, *Pentacme suavis*, and other species. Towards its northern limit in the Ruby Mines district it occurs in dry open forest on poor shallow soil, its chief associates being *Diospyros burmanica*, *Vitex pubescens*, *Pterocarpus macrocarpus*, *Anogeissus acuminata*, *Xylia dolabriformis*, *Terminalia tomentosa*, *Acacia Catechu*, and others, with bamboos, chiefly *Dendrocalamus strictus*: the trees are of small size. Towards its southern limit in the Magwe and Yamethin districts it occurs in dry forest of a similar type, which may be regarded as a transition between the scrub forests of the dry zone and the upper mixed deciduous forests occurring outside that zone.

[1] Report on the Exploration of the Forests of the South Andaman and other Islands, 1906, para. 23.

2. ANOGEISSUS, Wall.

This genus contains three well-defined Indian species ; *A. sericea*, Brandis, which occurs in parts of the Central Provinces and in the Panch Mahals, is possibly not distinct from *A. acuminata*, Wall. The fruit is small, dry, two-winged, terminating in a beak formed by the persistent calyx-tube ; the fruits are clustered in small globose heads. One of the chief peculiarities of this genus is the infertility of the seed, in spite of which natural reproduction often appears in great quantity, resulting in the case of *A. latifolia* and *A. pendula* in gregariousness. This question is discussed in dealing with *A. latifolia* ; it has been suggested that fertile seed is produced in quantity only in certain years, and that the cause of this is climatic.

Species 1. *A. latifolia*, Wall.; 2. *A. pendula*, Edgw.; 3. *A. acuminata*, Wall.

1. Anogeissus latifolia, Wall. Syn. *Conocarpus latifolia*, DC. Vern. *Dhaura, dhau, dhawa, bákli*, Hind. ; *Dindal, dinduga*, Kan. ; *Vellay naga*, Tam. ; *Chiriman*, Tel. (Fig. 205.)

A moderate-sized to large deciduous tree with a somewhat feathery rounded crown and drooping branchlets. Bark thin, smooth, greenish or greyish white, exfoliating in irregular thin rounded scales which leave shallow depressions ; the outer layer contains chlorophyll. The bark sheds rapidly, and rings of paint often disappear within two or three years of being applied.

The tree seldom attains very large dimensions, a girth of more than 6 ft. not being common. Mr. T. Carr recorded a sound tree 9 ft. 3 in. in girth in the Sarda range of the Haldwani forest division, United Provinces. A cross-section without bark in the silvicultural museum at Dehra Dun measures 8 ft. 9 in. in circumference ; this was cut from a tree in the United Provinces.

The wood, which is hard, very strong, and tough, is used for cart-axles, shoulder-poles, axe-handles, furniture, agricultural implements, poles and rafters, boat-building, and other purposes. The leaves are rich in tannin, and are collected for tanning purposes ; the bark is also used for tanning, and yields a gum much used in calico-printing. Apart from its economic uses the tree is useful silviculturally in clothing dry hill-sides, and is an important constituent in certain dry types of forest.

Distribution and habitat. Throughout the sub-Himalayan tract and outer hills from the Ravi to Nepal, ascending to 4,000 ft., Bihar, Chota Nagpur, Central India, and southwards throughout the greater part of the Indian Peninsula, ascending the hills of southern India to 4,000 ft. ; also in the dry country of Ceylon. Not in eastern Bengal, Assam, or Burma.

The tree is characteristic of deciduous forests, usually of a dry type, but is also common in sal forest and in other types of moderately moist forest. In the outer Himalaya it often marks a distinct zone towards the upper limit of the low-level species, at about 2,500–4,000 ft. ; here it is gregarious, forming almost pure crops or mixed with *Bauhinia retusa* and a few other species. In the Siwalik hills it occurs gregariously in the same way on sandstone and conglomerate, the chief species associated with it being *Buchanania latifolia*,

Ougeinia dalbergioides, *Terminalia tomentosa*, *Wendlandia exserta*, and *Pinus longifolia*. In the submontane forests of the Himalayan region it is often abundant, both in certain types of sal forest and in mixed forest without sal. A very common companion is *Terminalia tomentosa*, and on alluvial flats near streams the crop sometimes consists entirely of this species and *Anogeissus*; here the trees attain large dimensions.

In Chota Nagpur it is very common, especially on the drier hills, often growing more or less gregariously. In the hills of Central India it is likewise plentiful in some localities. In Gwalior it often forms an underwood in *Boswellia* forests. In the Central Provinces and Bombay it is a common constituent of the mixed deciduous forests, where it is at times gregarious, among its chief companions being teak, *Terminalia tomentosa*, *Lagerstroemia parviflora*, *Ougeinia dalbergioides*, *Diospyros Melanoxylon*, *Cassia Fistula*, and *Phyllanthus Emblica*.

In Bombay it is one of the commonest trees above *ghats*, particularly in Belgaum and Kanara; on the eastern (Dharwar) side of the North Kanara forest division it forms nearly pure crops over considerable areas. In the Madras Presidency it is perhaps more abundant than it is anywhere else, particularly in the south-east, in Madura and in Tinnevelly, where it may form as much as 50 per cent. of the crop on the upper dry slopes of the hills. It is plentiful in the eastern forests of Coorg, in many parts of Mysore and Hyderabad, and in the dry deciduous forests of Travancore up to 4,000 ft.

Generally speaking it avoids moist regions, but on the other hand it does not extend into the driest parts of India, being absent from Sind and rare in Ajmer-Merwara: in the drier regions of its habitat it is usually stunted and crooked, though this condition is often due in part to fire and maltreatment. It grows on a variety of geological formations, including sandstone, limestone, metamorphic rocks, trap, and laterite: it attains its largest dimensions, however, on deep alluvial or diluvial soil. It avoids swampy and badly-drained ground, and requires good drainage. In the natural habitat of the tree the absolute maximum shade temperature varies from 102° to 118° F., the absolute minimum from 30° to 60° F., and the normal rainfall from 25 to 90 in.

Leaf-shedding, flowering, and fruiting. The leaves turn a coppery red to reddish brown about November, and in the cold season the trees are very conspicuous with their deep red foliage. The leaves fall chiefly in February, the trees remaining leafless until April–May, when the new foliage appears. The insignificant greenish yellow flowers, in small globose heads, appear from June to September according to locality (August–September towards the northern limit of the species).

The small dry indehiscent fruits (Fig. 206, *a*), crowded in globose heads, are 0·15–0·25 in. in diameter, compressed, with a narrow wing on each side, yellowish brown, fairly hard. About 3,000–3,500 weigh 1 oz. They ripen from December to March, fall soon after ripening, and may be found scattered over the ground round the trees from February–March onwards.

As a rule the tree seeds abundantly every year, but the fertility of the seed is usually very poor; this question is considered under 'natural

reproduction '. Fertility tests can probably best be carried out on shaded well raised and watered beds of loose sand and gravel, as explained under ' artificial reproduction '.

GERMINATION (Fig. 206, *b*). Epigeous. The radicle emerges from the extremity of the fruit and descends. The hypocotyl and the cotyledonary petioles elongate, raising the cotyledons above ground. The shell of the fruit encloses the cotyledons for a time, falling with their expansion.

THE SEEDLING (Fig. 206).

Roots: primary root long, moderately thick, terete, tapering, woody or wiry: lateral roots few to moderate in number, short, fibrous, distributed down main root. *Hypocotyl* distinct from root, 0·1–0·3 in. long, terete or slightly compressed, minutely pubescent. *Cotyledons*: petiole 0·5–0·9 in. long, finely pubescent, often red: lamina 0·2–0·4 in. by 0·35–0·6 in., foliaceous, much broader than long, apex truncate or retuse, base tapering, entire, glabrous above, minutely pubescent beneath, green, often red beneath, prominently 3-veined from the base. *Stem* erect, terete, wiry, pubescent, often reddish; internodes 0·1–0·8 in. long. *Leaves*, first two sub-opposite or alternate, sometimes abortive and 0·1–0·2 in. long, subsequent normal leaves alternate, at first small, successively increasing in size. Stipules absent. Petiole up to 0·1 in. long. Lamina 0·4–2·8 in. by 0·3–1·1 in., elliptical ovate, acute or acuminate, mucronate, base acute, entire, glabrous above, glabrescent or minutely pubescent beneath, especially on the veins, margins finely ciliate, venation arched reticulate, veins often reddish on under surface.

The growth of the seedling is only moderate, a height of 4–8 in. being ordinarily attained by the end of the first season. The taproot attains a length of 18 in. or more in the same time. The seedlings suffer a little from frost, but the damage is not as a rule serious, and extends only to the wilting of the leaves. In dry localities the seedlings may die back annually for some years before they finally shoot up.

SILVICULTURAL CHARACTERS. The tree is a decided light-demander, though it can stand a slight amount of shade in early youth. Although it grows in dry types of forest it is sensitive to drought, and suffered much in the abnormal droughts of 1899–1900 in the Indian Peninsula and of 1907 and 1908 in Oudh: in the dry years from 1911 to 1914 in Jodhpur many young coppice-shoots died back and the stools did not recover. As regards its susceptibility to frost, Brandis notes that in January 1870, on the borders of Pertabgarh, south-west of Nimuch, he found it had been injured a good deal. It may, however, be found flourishing in grass-covered frosty blanks where tender species could not exist, for example on the flat land fringing the Siwalik hills along with other frost-hardy species such as *Stereospermum suavolens*, *Ougeinia dalbergioides*, and *Acacia Catechu*. It cannot therefore be considered a very frost-tender species. It is less susceptible to damage by browsing than many other species, even goats being not very partial to it. It suffers from fire, and in severely burnt areas it becomes gnarled and hollow. It produces root-suckers. If cut at the right season of the year it coppices and pollards well in most localities, but in experiments carried out in North Chanda, Central Provinces, in 1909, of trees pollarded only 16 per cent. produced pollard-shoots, while in the case of trees coppiced in different months the percentage of stools which produced coppice-shoots was: (1) April, 92; (2) May, 100; (3) June, 50; (4) July, 50; (5) August, nil; (6) September, nil. This shows that coppicing

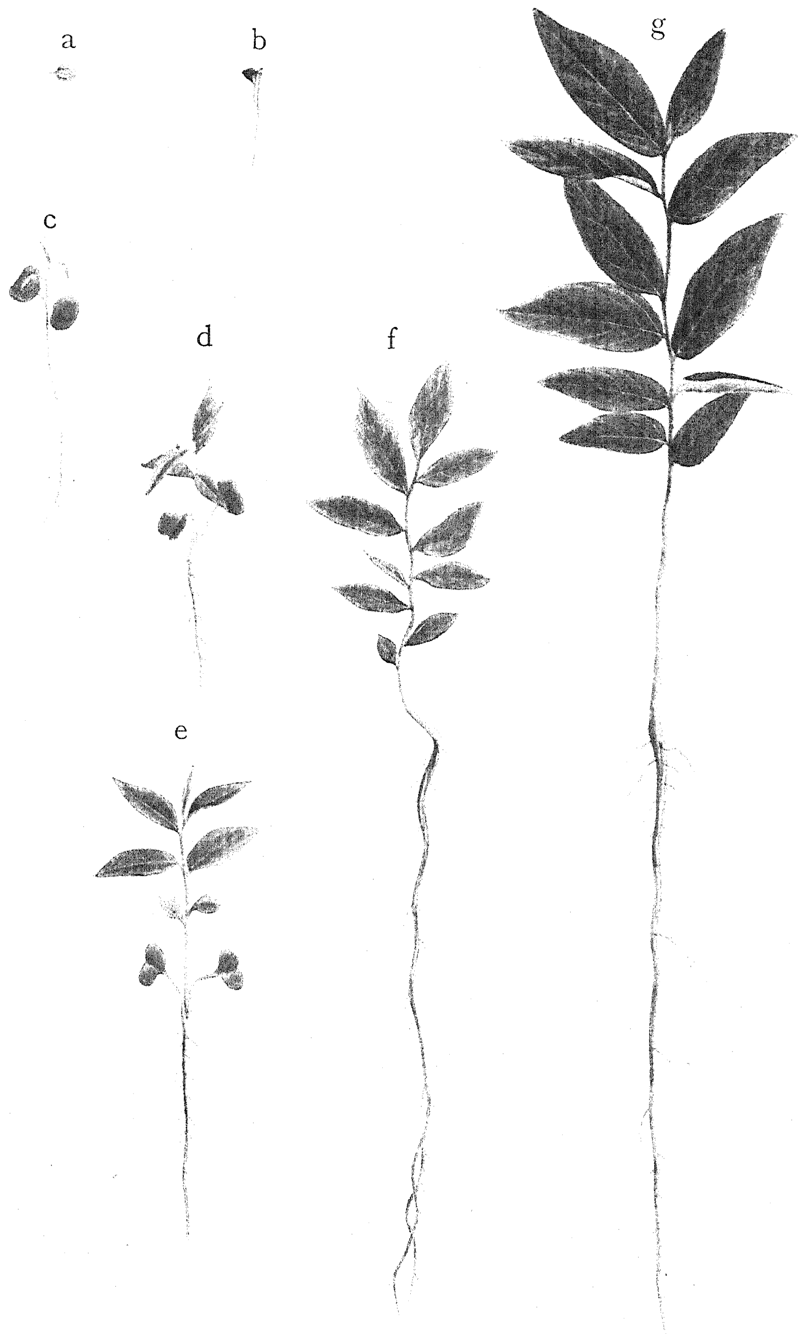

FIG. 206. *Anogeissus latifolia*—SEEDLING × $\frac{3}{8}$

a—Fruit b—Germination c - g—Development of seedling during first season

in the rainy season is unsuccessful. In an experimental coppice area in North Khandesh, Bombay, in 1903, the percentage of felled trees which yielded coppice-shoots was 60, the number of shoots per stool varying from 2 to 7. In experiments carried out by Mr. E. Marsden in the United Provinces pollarding was found to give better results than coppicing for the production of young leaves and twigs for tanning; the best season for pollarding was found to be not later than March, and the best results were obtained from branchy trees, girth being of less importance than branchiness for the production of numerous shoots.

NATURAL REPRODUCTION. The natural reproduction of this tree is not yet fully understood. Seedlings come up naturally, often in abundance, on newly exposed well-drained ground on stony hill-sides, on landslips, on abandoned cultivation, on open grassy areas as well as on alluvial ground. Reproduction is always best, however, where the drainage is perfect, dense crops of saplings appearing on the well-drained slopes of hills and on sandy or gravelly soil. Light is undoubtedly an important factor in the establishment of natural reproduction, which is often plentiful in open gaps and bare places, but the Bombay experiments described below under 'artificial reproduction' would indicate that shade and moisture are favourable to successful germination. Absence of weed-growth is also favourable, for the seedlings are very intolerant of suppression by weeds, and it is noteworthy that good reproduction has been observed to spring up on burnt areas, though its ultimate establishment is favoured by protection from fire and excessive grazing.

The want of fertility of the seed does not accord with the fact that reproduction often springs up in dense masses on well-drained hill-sides, and Mr. R. S. Pearson [1] has advanced a theory to explain this fact. Having noticed in the Panch Mahals that reproduction appeared in even-aged masses differing from each other by definite intervals of years, as determined by counting rings on cut seedlings and saplings, he ascertained that the years in which reproduction took place were those following on years of deficient rainfall. He surmised therefore that whereas under normal conditions the tree produces little or no fertile seed, the production of fertile seed is stimulated by years of drought. This theory is well worth following up by fertility tests of seeds carried out annually for a series of years, including seasons of good and of deficient rainfall, the results so obtained being supplemented by comparative observations of the state of reproduction in the forest.

Mr. A. K. Desai [2] notes that seedlings sprang up in great abundance on flat grass-covered ground in the Panch Mahals as a result of the opening out of the forests by the removal of dead timber killed by the drought of 1899–1900. If Mr. Pearson's theory be correct, the production of fertile seed as a result of the drought might be considered to be the main factor which induced this reproduction.

Mr. H. Tireman [3] remarks on the profuse reproduction of *Anogeissus* which springs up and establishes itself in the Coorg forests on the removal, after burning, of the dense growth of lantana which infests them. The germination of the seed is evidently favoured by the clean bare soil under

[1] Ind. Forester, xxxiii (1907), p. 231. [2] *Ibid.*, xxxiv (1908), p. 15.
[3] *Ibid.*, xlii (1916), p. 390.

the lantana, and the rapid growth of the seedlings, when the lantana is removed, is stimulated by the absence of grass for the first year or two and the fact that the lantana enriches the soil.

ARTIFICIAL REPRODUCTION. The fruits require to be collected when the heads commence to break up, and not before. The infertility of the seeds is a serious drawback to artificial reproduction, and if the theory just referred to holds good the best results would seem to be obtainable after dry years when a fertile crop of seed is obtained. Under ordinary conditions the infertility of the seed would preclude any great success by direct sowings, though in years of fertile seed-production they should prove successful on well-drained porous ground. Many years ago Mr. Haines carried out successful sowings on heaps of loose earth and rubble at Chaibassa, Chota Nagpur. Mr. Pearson[1] notes that he obtained successful germination in the Panch Mahals, Bombay, by sowing the seed on well-irrigated raised beds, the soil being mixed with a large quantity of coarse sand; the seed was sown in June and lightly watered by hand every day. Germination commenced after about twenty days; it was successful only where the beds were well shaded by a thick covering of leaves and branches some 18 in. above the ground; under this shade a large mass of seedlings came up, whereas in beds exposed to the sun hardly any seed germinated. Seedlings can be transplanted without difficulty.

SILVICULTURAL TREATMENT. At present this tree is worked only as a component species of mixed forests, either as coppice-with-standards or under selection and improvement fellings, when, however, it is frequently cut out in the interests of more valuable species such as teak or sal.

As the leaves and bark give promise of furnishing valuable tanning material, it is not unlikely that some system will have to be devised before long for working this species for the production of regular supplies of bark and leaves. The young tender leaves and shoots are richest in tannin. Short rotation coppice, or some modification of it, suggests itself, though the best method remains to be discovered by experiment. Meanwhile the following experiment carried out in Central India is of interest:

A trial coupe of 6 acres on the slopes of the Sharda Devi hill, about $2\frac{1}{2}$ miles from Maihar in Central India, was coppiced in January 1916, about 1,500 trees having been cut to ground-level, leaving rounded stools. The trees were all small and badly shaped. The yield obtained from these was:

Dry leaves . . .	31 maunds (of approximately 82 lb. each).
Dry bark . . .	41 maunds.
Dry fuel . . .	214 maunds.

Within two months of cutting, strong shoots of a bushy growth appeared, covered with fresh leaves rich in tannin. The first flush of leaves was collected and weighed 3 maunds. The method of working proposed in this tract is to continue the collection of the fresh leaves from the coppice-shoots for two or three years and then to leave one strong shoot on each stool to develop into a pole before any further coppicing is carried out. Fresh new leaves are found to be produced on the young coppice-shoots very soon after the shoots have been stripped of leaves.

[1] Ind. Forester, xxxi (1905), p. 637.

The following programme of pollarding and plucking has been adopted tentatively in Central India :

October, November, December : collection of old leaves, only green leaves being suitable.

January, February, March : pollarding and collection of twig bark, once in three years.

April, May, June : collection of sumach (young leaves) once a month ; this is the most important crop.

July, August, September : continued collection of sumach if drying arrangements are possible.

Rate of growth. The following figures are available of girth measurements in sample plots in high forest :

Anogeissus latifolia : girth increment in high forest sample plots.

Province.	Forest division.	Locality.	No. of years under observation.	No. of trees under observation.	Girth classes. ft.	Mean annual girth increment for period. in.
United Provinces	Lansdowne	Chaukhamb	17	8	$1\frac{1}{2}$–3	0·29
		Jogichaur	12	2	$1\frac{1}{2}$–3	0·14
		Giwain	4	2	$1\frac{1}{2}$–3	0·27
		,,	12	10	$1\frac{1}{2}$–3	0·63
	Haldwani	Khonani	6	1	$1\frac{1}{2}$–3	0·20
	Gonda	Chandanpur	2	13	$1\frac{1}{2}$–4	0·16
		Sakra	2	16	$1\frac{1}{2}$–3	0·24
Central Provinces	Balaghat	Baihar and Raigarh ranges	8	8	1–2	0·20
Bihar and Orissa	Singhbhum	Tirilposi	25	2	3–4	0·30
				3	4–5	0·32
		Samta-Hendakuli	11	1	2–3	0·37
				4	3–4	0·35
				2	4–5	0·76

Some of these figures probably under-estimate the rate of growth actually attainable, since all these plots are in sal forest, and their main object is to estimate the rate of growth of sal ; hence in thinned plots dominant accessory species would be cut out, and the increment figures would refer to dominated or suppressed trees. Trees raised from seed sown in 1901 by Mr. Haines in the forest garden at Chaibassa, Chota Nagpur, attained the following dimensions in sixteen years :

Height. ft.	Girth. ft.	in.	
35	1	$10\frac{1}{2}$	
$28\frac{1}{2}$	1	$10\frac{1}{4}$	
29	1	$6\frac{1}{4}$	
28	1	$0\frac{1}{2}$	(half suppressed)
29	1	$3\frac{1}{2}$	

The annual rings are tolerably clear. Gamble's specimens gave an average of 7 rings per inch of radius, or a mean annual girth increment of 0·9 in. A cross-section in the silvicultural museum at Dehra Dun, measuring 8 ft. 9 in. in girth without bark, had 176 rings, giving a mean annual girth increment of 0·6 in.

Measurements of natural saplings in the Panch Mahals, Bombay, recorded

by Mr. Pearson,[1] give some idea of the rate of growth in youth : the ages were determined by ring-countings on the stumps of felled saplings. The measurements are as follows :

Anogeissus latifolia : rate of growth of natural saplings, Panch Mahals, Bombay.

Age. years.	No. of plants.	Girth.	Height.	Remarks.
		At base.		
4	1	..	7 ft. 4 in.	These measurements are of dominant plants ; very small plants of the same age were also met with.
5	3	3–4 in.	8–10 ft.	
5	3	..	2, 5, and 9 ft.	
		At 4 ft.		
20	5	8, 11, 11, 11½, and 13½ in.	25, 25, 15, 26, and 20 ft. respectively	

The following table summarizes the available results of measurements in coppice coupes :

Anogeissus latifolia : rate of growth of coppice.

Mean girth and height in different localities.

Age.	Saitba block, Kolhan, Bihar and Orissa (1916).		Dehra Dun (A. F. Broun, 1886).		Gorakhpur, U.P. (C. M. McCrie, 1910).		Tikri, Gonda, U.P. (1911).	Bhandara, C.P. (1912–13).	N. Khandesh, Bombay (1905).
years.	girth.	height.	girth.	height.	girth.	height.	height.	height.	height.
	in.	ft.	in.	ft.	in.	ft.	ft.	ft.	ft.
1	..	..	..	..	..	..	8	6·2	2·5
2	1·3	4·5	..	..	..	..	..	..	..
4	2·5	8·2	..	..	..	..	..	..	..
6	3·6	10·8	..	..	..	..	..	..	..
8	4·6	13·0	7·5	12·0	..	..	..	..	..
10	5·5	15·0	..	..	..	..	..	..	..
12	6·4	16·8	..	..	..	..	..	..	..
14	7·2	18·0	..	..	..	..	..	..	..
15	..	..	..	..	7·25	22·5	..	..	..

2. **Anogeissus pendula,** Edgew. Vern. *Dhokra*, Ajmer-Merwara ; *Kardhai*, Central India.

A small tree with a short usually crooked bole, readily distinguished from *A. latifolia* by its smaller leaves and graceful slender drooping branches. In exceptional cases the tree reaches a height of 30–40 ft. and a girth of 5 ft., but ordinarily the height is about 20 ft. and the girth 2–3 ft., the stem branching at a height of about 4–5 ft.

The bole yields little or no timber, but poles cut from the branches are in demand for building and other purposes. The leaves contain tannin, and the tree has possibilities as a producer of sumach. In the dry regions in which it occurs this is an important tree, not only as a source of timber and fuel, but also for clothing dry tracts.

Distribution and habitat. The tree has a decidedly limited distribution. It extends from the Aravalli hills in Rajputana to Bundelkhand, and from the Kishengarh state and the Jhansi, Hamirpur, and Banda districts of the United Provinces on the north to the Nerbudda in Nimar and the Panch

[1] Ind. Forester, xxxiii (1907), p. 234.

FIG. 207. *Anogeissus pendula*—SEEDLING

a—Fruit × 1½ b—Germination × 1½ c-f—Development of seedling during first season × ¾

Mahals in the south. It is essentially a tree of the dry hot regions; within its natural habitat the absolute maximum shade temperature varies from 115° to 120° F., the absolute minimum from 30° to 38° F., and the normal rainfall from 17 to 35 in.

The tree is typically gregarious, sometimes forming pure forests and sometimes occurring in mixture with a few other species. In the Aravalli hills of Rajputana, Ajmer and Merwara, which consist of metamorphic and sub-metamorphic rocks—chiefly gneiss, schist, slate, and quartzite with occasional limestone and trap—it often forms almost pure forests of considerable extent, usually occupying the lower and more gentle slopes. The ridges and upper slopes are occupied mainly by *Boswellia serrata*, below which and extending to the foot of the hills *Anogeissus pendula* occurs, particularly if the soil is good. Where the slopes are gentle this tree may extend to the hill-tops; where the soil is poor it is replaced by *Acacia rupestris*. Besides the two species mentioned, its more important associates in this region are *Acacia Catechu*, *Albizzia odoratissima*, *Dalbergia lanceolaria*, *Dichrostachys cinerea*, *Bauhinia racemosa*, and *Grewia* spp., while on the level ground below the *Anogeissus* forests the prevailing species is *Zizyphus Jujuba*.

In the Jhansi district the tree forms practically pure forests on quartzite ridges, other species such as *Diospyros Melanoxylon*, *Acacia Catechu*, *Zizyphus Xylopyrus*, *Bauhinia racemosa*, *Odina Wodier*, and *Butea frondosa* being occasionally scattered with it. The trees here are small and badly shaped, though the forest is often well stocked. Another type of forest in this district is that occurring on undulating to hilly ground on a gneiss formation; here *Anogeissus pendula* occurs in pure patches or in mixture with *A. latifolia* and *Acacia Catechu*, while the other species previously mentioned occasionally make their appearance.

Leaf-shedding, flowering, and fruiting. The leaves, which are green throughout the rainy season, turn a beautiful reddish brown colour in the cold season and commence falling in January, the trees becoming leafless about March and remaining so until about May–June, when the new foliage appears. The small flower-heads, about $\frac{1}{4}$ in. in diameter or less, appear towards the end of the rainy season. The fruits (Fig. 207, *a*) ripen December–January; they are small, winged, and nearly orbicular, about 2,700 weighing 1 oz. The tree fruits abundantly nearly every year, but the germinative power of the seed, like that of *A. latifolia*, is usually poor, though tests carried out at Dehra Dun gave a higher percentage of fertility than in the case of *A. latifolia*.

Germination (Fig. 207, *b*). Epigeous. The radicle emerges from the extremity of the fruit and descends. The hypocotyl elongates, raising the cotyledons above ground. The shell of the fruit encloses the cotyledons at first, and falls with their expansion.

The seedling (Fig. 207).

Roots: primary root long, thin, terete, wiry: lateral roots moderate in number, short or moderate in length, fibrous, distributed down main root. *Hypocotyl* distinct from root, 0·5–0·6 in. long, terete, minutely tomentose. *Cotyledons*: petiole 0·1 in. long or less: lamina 0·15–0·25 in. by 0·35–0·55 in., foliaceous, reniform, much broader than long, truncate or slightly retuse, base truncate or slightly lobed, entire, green, glabrous. *Stem* erect, terete, wiry, tomentose; internodes up to 0·5 in. long. *Leaves* simple, first pair usually

opposite or sub-opposite, subsequent leaves alternate, exstipulate. Petiole less than 0·1 in. long. Lamina 0·2–1 in. by 0·1–0·5 in., ovate, acute or acuminate, mucronate, entire, glabrescent above, pubescent on veins beneath, gland-dotted.

SILVICULTURAL CHARACTERS. The tree stands a fair amount of shade in youth, but as saplings appear in quantity in open gaps it seems to require a good deal of light for successful development. It is frost-hardy, but suffers severely from drought in abnormally dry years: in the famine of 1892 in Ajmer the branches of the trees were extensively killed, but new shoots were produced from the stem. The tree coppices and pollards well, but the growth of the coppice-shoots is slow. It produces root-suckers freely.

NATURAL REPRODUCTION. The factors which affect natural reproduction require further study. Reproduction by root-suckers is often plentiful, but seedling reproduction is also frequently good. Like *A. latifolia* the tree tends to regenerate in even-aged masses, and this would indicate that the theory put forward with regard to that species, namely that the production of fertile seed in quantity takes place only after years of scanty rainfall, might apply equally to *A. pendula*. In 1913 seed was sown at Dehra Dun along a ridge of loose earth and also in the trench from which the earth was dug. No seed germinated on the ridge, but several seedlings appeared in the loose alluvial soil accumulated in the trench; none of these, however, survived the rainy season, being killed by an excess of moisture. Definite conclusions cannot be drawn from this solitary experiment, but it might be inferred that, as in the case of *A. latifolia*, shade, or rather protection from a hot sun, is favourable to germination, and also that the seedlings cannot tolerate an excess of moisture.

SILVICULTURAL TREATMENT. Forests of *Anogeissus pendula* are at present treated either under coppice-with-standards or under improvement fellings for the removal of old badly shaped trees over promising young natural crops. A coppice rotation of twenty years in Ajmer has been found to be too short for the production of material of a useful size. In the Jhansi forests Mr. J. Whitehead has suggested that after a provisional period of improvement fellings the most suitable method of treatment, in view of the tendency of this tree to come up in even-aged masses, would be to regenerate in even-aged crops under a shelterwood.[1]

RATE OF GROWTH. A cross-section 3 ft. 2 in. in girth, in the silvicultural museum at Dehra Dun, shows 42 rings, representing a mean annual girth increment of 0·9 in., which is fairly fast. This does not accord with observations in the forest, at all events in the case of young plants, whose growth is decidedly slow. Coppice-shoots likewise grow somewhat slowly, particularly in the earlier years. In Ajmer shoots seven years old had a height of 7–8 ft. and a girth of 3–4 in., while shoots eight years old had a height of 10–12 ft. and a girth of 4–7 in.[2]

3. **Anogeissus acuminata,** Wall. Vern. *Chakwa*, Beng.; *Pasi*, Tel.; *Yôn*, Burm.

A large handsome deciduous tree with a tall straight bole and graceful

[1] Working Plan for the Forests of the Jhansi and Banda Districts, 1911.

[2] Ajmer-Merwara Working Plan, 1909.

drooping branches. Bark dark grey, in Burma often covered with small globular pustules. The tree is variable. In Burma Kurz distinguishes two varieties: var. 1. *genuina*, with densely pustular bark, frequent in the mixed forests all over Burma; and var. 2. *phillyreaefolia*, with smaller leaves, and bark more or less destitute of pustules, restricted to the savannah and swamp forests of the alluvial plains of Prome and Pegu, and extending to Upper Burma. Haines distinguishes three varieties in Chota Nagpur, of which complete material is wanting.

The wood is moderately hard, but is inferior to that of *A. latifolia*; it is not durable, and warps and cracks in seasoning.

DISTRIBUTION AND HABITAT. The tree is found in limited quantity in Chota Nagpur (Singhbhum district), extending southward through Orissa, the Northern Circars, and the Chanda district, Central Provinces. It is found typically along the banks of streams on alluvial ground. It occurs in the Chittagong hill tracts, and is a common forest tree throughout the greater part of Burma, extending to the borders of the dry zone. In Burma it is frequent not only along river banks, but also in the upper mixed deciduous forests with teak and its associates. It is, however, perhaps most plentiful in the lower mixed deciduous forests of the plains, along with *Dillenia pentagyna*, *Terminalia tomentosa*, *T. belerica*, *T. Chebula*, *Schleichera trijuga*, *Odina Wodier*, *Dalbergia cultrata*, *Vitex glabrata*, *Eugenia Jambolana*, *Adina cordifolia*, *Stephegyne diversifolia*, and in the better drained localities teak, *Xylia dolabriformis*, and *Homalium tomentosum*. It extends into low-lying swampy ground, and is one of the most characteristic species of the freshwater swamp forests of the plains, which are inundated during the rainy season. It is, however, not confined to moist localities, but is common in certain dry regions, for example in the Ruby Mines district, where it occurs in open dry forest on somewhat poor shallow soil, the trees being of small size; here it is associated with *Terminalia tomentosa*, *Acacia Catechu*, *Diospyros burmanica*, *Vitex pubescens*, *Pterocarpus macrocarpus*, and others.

In its natural habitat the absolute maximum shade temperature varies from 100° to 115° F., the absolute minimum from 40° to 55° F., and the normal rainfall from 35 to 120 in. or more.

LEAF-SHEDDING, FLOWERING, AND FRUITING. In Burma the tree is leafless for a short time in the hot season; the flowers appear in February–March, and the fruits ripen in April–May, falling as soon as they ripen. In Chota Nagpur, according to Haines, the flowers appear in March–April and the fruits commence ripening in April. About 1,100 to 1,800 of the fruits weigh 1 oz. The seed, like that of other species of this genus, is very unfertile. No fewer than fifteen tests under different conditions were carried out at Dehra Dun in two separate years with samples of seed from three different localities in Burma, and in no case did a single seed germinate.

NATURAL REPRODUCTION. Notwithstanding the unfertile nature of the seed, natural reproduction of this tree in Burma is often very good, young plants sometimes forming dense even-aged thickets, particularly on alluvial ground in places where the fruits have been washed into heaps along with silt. In the case of *A. latifolia* it has been suggested that fertile seed is produced only in certain years, probably following on seasons of deficient rainfall.

Although it is possible that in the case of *A. acuminata* the production of quantities of fertile seed may take place only in certain years, the reason for this cannot be any deficiency of rainfall, since this does not occur throughout the greater part of its habitat in Burma.

3. LUMNITZERA, Willd.

Lumnitzera racemosa, Willd. Vern. *Kirpa*, Beng.; *Yinyè*, Burm.

An evergreen shrub or small tree of the mangrove swamps along the coasts of India and Burma, an account of which is given on pp. 496–500. It extends also into the tidal forests behind the mangrove swamps, occurring chiefly on the banks of streams. The wood is hard and durable, and is used for house-posts and for fuel. Flowers March–April; fruits September (Talbot). Its root-system is superficial, the roots bending out of the mud in the form of knees for breathing purposes.

ORDER XXVIII. MYRTACEAE

An important order containing some useful Indian trees (*Eugenia*, *Careya*) and a number of introduced species, mainly of the great Australasian genus *Eucalyptus*, several of which have become thoroughly acclimatized in India. Among trees and shrubs yielding edible fruits may be mentioned *Psidium Guayava*, Linn., the guava, introduced from tropical America and grown all over India, *Eugenia Jambos*, *E. Jambolana*, and other species of *Eugenia*, and *Rhodomyrtus tomentosa*, Wight, the hill gooseberry of the Nilgiris. Many of the species have aromatic and coriaceous leaves, and exhibit xerophytic characters, as seen for example in the pendulous leaves of *Eucalyptus*. Their silvicultural requirements vary considerably even in different species of the same genus. Of those which thrive in moist and even swampy ground may be mentioned *Barringtonia* and several species of *Eucalyptus* and *Eugenia*, while other members of the last two genera are found on dry poor ground. Of hardy fire-resisting species characteristic of burnt savannah lands, the most important are *Careya arborea* and *Eugenia operculata*. Many of the members of this order coppice with great vigour.

Genera 1. Eugenia, Linn.; 2. Eucalyptus, L'Hérit.; 3. Barringtonia, Forst.; 4. Careya, Roxb.; 5. Planchonia, Bl.

1. EUGENIA, Linn.

This genus is probably richer in tree species than any other Indian genus. Brandis (*Indian Trees*) enumerates no fewer than 79 species, chiefly trees, with a few shrubs; of these 76 or 77 are indigenous. They are nearly always evergreen, with gland-dotted often coriaceous leaves, which with rare exceptions are opposite. The fruit is a one- or few-seeded berry, often succulent, sometimes nearly dry. The great majority of the species are moisture-loving, and are found in moist localities, often in evergreen forest, while several grow along the banks and in the beds of streams. *E. formosa*, Wall., a large-leaved species with ternate leaves up to 18 in. long, often grows in the beds of perennial

FIG. 208. *Eugenia Jambolana* on bank of stream, United Provinces.

FIG. 209. *Eugenia Jambolana* growing gregariously along bank of stream and worked as coppice, Gorakhpur district, United Provinces.

streams with its roots permanently in water. *E. Heyneana*, Wall., a willow-like shrubby species, grows in the beds of streams, and is often inundated for a considerable period during the rainy season. *E. Jambolana*, Lam., and others, sometimes grow under similar conditions. Some species, on the other hand, grow in dry types of forest and exhibit xerophytic tendencies. Thus *E. Jambolana* itself is the most characteristic tree of the dwarf evergreen formation on the laterite of the Mahableshwar plateau, Bombay, while the variety *caryophyllaefolia*, Lam., of the same species, is found on dry hills in Chota Nagpur. *E. grandis*, Wight, occurs on dry ridges in Upper Burma.

Several species of this genus are rare or local, and on the whole the trees are, with one or two exceptions, not of great importance in Indian forestry. By far the most important generally is *E. Jambolana*, Lam. In the sal forests of northern India, *E. operculata*, Roxb., is a useful species from a silvicultural point of view.

Species 1. *E. Jambolana*, Lam.; 2. *E. operculata*, Roxb.; 3. *E. Jambos*, Linn.

1. **Eugenia Jambolana**, Lam. Black plum. Vern. *Jáman*, Hind.; *Jambul*, Mar.; *Nerlu*, Kan.; *Naval*, Tam.; *Neredu*, Tel.; *Thabyè*, Burm. (Fig. 208.)

A large evergreen tree with a dense shady much-branched crown of shining dark green foliage and usually a rather crooked bole. Bark up to 1 in. thick, light to dark grey or brown, fairly smooth, with shallow depressions caused by exfoliation, red inside. Wood moderately hard, fairly durable, used for common building, agricultural implements, well curbs, and other purposes; an excellent fuel. This is an important forest tree, and is also largely planted on roadsides and in gardens for shade or ornament and for the sake of its edible fruits. It is variable as regards the shape of the leaves and the size and shape of the flowers and the fruits.

Sometimes it reaches a very large girth: Mr. J. C. McDonnell [1] records one 20 ft. 6 in. in girth by the Saruinsar lake, Jammu.

DISTRIBUTION AND HABITAT. Common throughout India and Burma, except in the most arid regions. Also in the Andamans, Ceylon, the Malay Archipelago, and southward to Australia. In the Himalayan valleys it ascends to 4,000 ft. or sometimes more, and in the Nilgiris to 6,000 ft. It is found in a variety of situations, but most typically along streams and in damp and even marshy localities, where it is often gregarious (see Figs. 209, 211). In the Indian Peninsula a variety with narrow leaves is very common on alluvial sand or loam in the beds and along the banks of watercourses which are often dry for several months in the year. The tree is, however, by no means confined to very moist situations. It is a common constituent of the sal forests. It is the commonest species of the stunted evergreen forest on the laterite of the Mahableshwar plateau in the Bombay Presidency, forming roughly 50 per cent. of the stock and associated with *Actinodaphne Hookeri*, *Memecylon edule*, *Flacourtia Ramontchi*, *Terminalia Chebula*, *Olea dioica*, and *Canthium didymum*. The plateau is exposed, the ground often rocky, and the soil shallow, while the rainfall is heavy (over 200 in.), most of the rain falling in July and August; the trees seldom grow more than 25 ft. high, and have short thick boles and low flat crowns.

[1] Ind. Forester, xxix (1903), p. 152.

The narrow-leaved variety, *caryophyllaefolia*, Lam., is mentioned by Haines [1] as being very common in dry open forest on the hills of Singhbhum, Palamau, and Manbhum ; this variety, as noted below, exhibits the xerophytic character of dying back in the seedling stage.

In Burma the tree occurs in various types of mixed deciduous forest, both upper and lower, in tropical evergreen forest, and in *indaing* (dry diptero-carp) forest on laterite, here again occurring in a xerophytic environment. In Travancore it is common on the Peermerd plateau at 4,000 ft., and elsewhere in the evergreen forests of the hills (Bourdillon).

In its natural habitat in India and Burma the absolute maximum shade temperature varies from 95° to 118° F., the absolute minimum from 28° to 65° F., and the normal rainfall from 35 to over 200 in.

LEAF-SHEDDING, FLOWERING, AND FRUITING. The leaves usually commence falling about January and continue falling during February and March. The new leaves, which are coppery red in colour, appear in February–March. In dry localities the trees become almost, if not quite, leafless for a short time early in the hot season. Sometimes trees with large quantities of blossom become almost leafless.

The panicles of small greenish white sweet-scented flowers appear chiefly from March to May. The fruit (Fig. 210, *a*), which ripens from June to August, is an oblong-obovoid or sub-globose juicy berry, 0·5–1 in. long, or larger under cultivation, purplish-black, smooth and shining when ripe, with a thin skin and a pink succulent flesh, which is edible though somewhat astringent. The seed (Fig. 210, *b*) is 0·4–0·8 in. long, shaped like the fruit, or two to five angular and irregularly shaped seeds are compressed together into a mass resembling a single seed, the whole enclosed in a sub-coriaceous covering.

The germinative power of fresh seed is high, but the seed very quickly loses its vitality. The fruits fall as soon as they ripen ; they are eagerly devoured by birds and flying foxes, and the seed is spread by their agency.

GERMINATION (Fig. 210, *c*, *d*). Hypogeous. The covering enclosing the seeds quickly rots off, leaving the green interior (cotyledons), which usually breaks up into two or more portions, from each of which a seedling is produced ; usually two or three, sometimes four or even five, seedlings emerge from one fruit ; the cotyledons remain in or on the ground.

THE SEEDLING (Fig. 210).

Roots : primary root moderately long and thick, terete, tapering, wiry : lateral roots numerous, moderately long, fibrous, distributed down main root or often crowded at its base. *Hypocotyl* very short and scarcely distinguishable, subterranean. *Cotyledons* irregular in shape and size, angular, fleshly, green, subterranean. *Stem* erect, quadrangular, green or pinkish, glabrous ; internodes 0·2–1·2 in. long. *Leaves* simple, exstipulate, first few often abortive, 0·1–0·2 in. long, sometimes alternate or sub-opposite, subsequent normal leaves opposite. Petiole 0·1 in. long or less, channelled above. Lamina 0·7–2 in. by 0·4–1 in., ovate, obovate or elliptical, apex acute or sometimes obtuse, base acute, entire, glabrous, coriaceous, aromatic when crushed.

The development of the seedling is slow during the first season, but under favourable conditions is more rapid during the second and subsequent years.

[1] For. Flora Chota Nagpur, p. 351.

FIG. 210. *Eugenia Jambolana*—SEEDLING × $\frac{1}{2}$

a—Fruits b—Seed c - d—Germination stages e - h—Development of seedling during first season
i—Seedling early in second season

In the case of the normal moisture-loving variety seedlings are very sensitive to drought if exposed to the sun, mortality commencing as early as September or October, and being particularly common during the subsequent hot season. Even under shade, seedlings have been observed to die off on dry ground. Soil moisture, indeed, appears to be of more importance than shade, since seedlings develop well even if exposed to the sun, provided the soil is kept moist. Under natural conditions, however, or where watering is not carried out, shade is of great benefit in preventing the desiccation of the soil and the death of the seedlings.

A striking instance of the value of shade occurred in connexion with experimental line sowings at Dehra Dun. Two lines of *Eugenia Jambolana*, $1\frac{1}{2}$ ft. apart, were sown early in the rains along a clear strip 3 ft. wide, with the object of ascertaining the value of this species as a nurse to sal, a line of which was sown between the two lines of *Eugenia*. The strip ran from north-west to south-east, and on either side of it field crops (lesser millet) were sown; these field crops grew rapidly and attained a height of $3\frac{1}{2}$ ft. by the end of the rains. The direction of the strip was such that one line of *Eugenia* received shade from the sun from midday onwards, while the other line was exposed to the sun. The seed germinated along both lines, and the seedlings developed well during the rainy season. On the sunny line, however, high mortality from drought occurred in September–October, and continued to some extent subsequently, the result being that whereas the shady line continued to be well stocked with vigorous seedlings, very few plants survived until the following rains in the parallel line exposed to the sun. Fig. 212 shows the appearance of the two lines a year after sowing.

In the case of var. *caryophyllaefolia*, Lam., I have noticed numerous seedlings in Singhbhum in open hill forest, growing on the driest ground in situations exposed to the sun; these seedlings, like those of many other species in dry localities, were observed to have died back annually for some years in their early stages, new shoots having been sent up each year from the base or from lateral buds. This great dissimilarity in the habit of this form from that of the normal seedling lends colour to Haines's suggestion as to this form being a separate species.

The seedling is capable of struggling well amongst weeds, but its development suffers. Weeding and watering, particularly the former, have a marked effect on its growth and vigour. On stiff soil the development is poor. Where, as is frequently the case, the seedlings are in dense masses, the more vigorous individuals rapidly suppress the more weakly plants. The seedlings are somewhat frost-tender, particularly on grassy ground, where they are frequently killed back. The season's growth continues until November–December, new growth commencing in February or March (northern India). The taproot reaches only a moderate length during the first season, showing greater development during the second year, when it attains a length up to 2 ft. or more.

The following measurements, made in experimental plots at Dehra Dun, give some indication of the dimensions attained by young plants under different conditions:

Eugenia Jambolana: development of seedlings, Dehra Dun.

Condition under which grown.	Height and other particulars at end of season. 1st season.	2nd season.	3rd season.
(1) Nursery plants watered and weeded	Maximum 0 ft. 4½ in.		
(2) Irrigated sowings, full sunlight, weeded	Maximum 0 ft. 6¼ in.	0 ft. 4 in.–4 ft. 1 in.	Maximum 8 ft. 0 in. (dense mass of strong thick-stemmed plants)
(3) Irrigated sowings, full sunlight, unweeded	Maximum 0 ft. 6 in.	0 ft. 3 in.–1 ft. 3 in.	0 ft. 8 in.–3 ft. 1 in. (condition somewhat poor)
(4) Unirrigated sowings, full sunlight, weeded	Maximum 0 ft. 10½ in.	0 ft. 7 in.–3 ft. 8 in. (vigorous, the larger suppressing the smaller)	
(5) Unirrigated sowings, full sunlight, unweeded	Maximum 0 ft. 6 in.	0 ft. 6½ in.–0 ft. 10 in.	
(6) Unirrigated sowings, in partial shade, weeded	Maximum 0 ft. 4½ in.	Maximum 2 ft. 3 in.	
(7) Unirrigated sowings, in partial shade, weeded	Maximum 0 ft. 5 in.	Maximum 2 ft. 0 in.	
(8) Transplants, in partial shade	Maximum 0 ft. 3 in.	Maximum 1 ft. 6 in.	0 ft. 11 in.–2 ft. 7 in.

Nos. 2 to 5 demonstrate the great value of weeding. Fig. 213 shows Nos. 2 and 3 during the second season; the effect of weeding, as shown on the left of the staff, is very marked in comparison with the unweeded plot on the right of it.

SILVICULTURAL CHARACTERS. *Eugenia Jambolana* is a shade-bearer, particularly in youth; dense masses of young plants may be found coming up under moderate shade near streams and in other moist places, while seedlings and saplings are often found under shade in sal forest and other types of forest. Although somewhat frost-tender in youth, it is hardier later, and in the abnormal frost of 1905 in northern India it was not much affected. In the abnormal drought of 1907 and 1908 in Oudh it proved to be hardy in the sal forests, but along streams and in swamps it suffered when the water dried up. It is not readily browsed by cattle.

The tree possesses remarkable coppicing power, shoots being produced in large quantities, chiefly round the periphery of the cut surface of the stool: large stumps as well as small ones produce shoots as a rule. Figs. 209, 211, and 215 show the appearance of pure coppice on rich alluvial land, subject to inundation in the rainy season, along the banks of streams in the Gorakhpur district, United Provinces. At an age of four years, with a height of 15 ft., there are often more than thirty shoots on one stump, more than half of them being usually dominant. The soil requirements of the tree have already been alluded to; they are somewhat contradictory, though the differences appear in some cases to coincide with well-marked botanical varieties.

NATURAL REPRODUCTION. The fruits fall in quantity under and around the parent trees early in the rainy season; the seeds are washed into heaps by the rain, germination quickly taking place on moist ground and in pools of mud. Each fruit may produce from one to four or even five seedlings clustered together, and the seedlings often appear in dense masses: this is particularly the case on alluvial ground, where as many as 100 seedlings about 6 in. high to the square foot have been counted after the end of the rainy

FIG. 211. *Eugenia Jambolana* coppice 30 ft. high in process of being felled on swampy ground, Gorakhpur district, United Provinces.

A B

FIG. 212. *Eugenia Jambolana*, line sowings in second year, showing beneficial effect of side shade, Dehra Dun. Line on left (A) exposed to the sun for a considerable part of the day, with the result that nearly all the plants have died of drought: line on right (B) receives side shade for most of the day, with the result that there has been little or no mortality from drought.

season on sandy alluvium. Fig. 214 shows profuse growth of seedlings at the end of the first season. Sometimes two or three tiers of seedlings of different years may be found under the same seed-bearer, showing to what an extent the young plants will stand shade. Seedlings often occur sporadically in the forest where there are no seed-bearers in the neighbourhood, the seed having been disseminated by the agency of birds. The necessity for soil moisture in the establishment of natural reproduction and the mortality which takes place on dry ground, even under shade, have already been noted under 'the seedling'; indeed, the value of shade appears to lie mainly in its power of preventing desiccation of the soil.

The exceptional case in which natural seedlings of var. *caryophyllaefolia* establish themselves on dry hilly ground after dying back for some years in succession has already been alluded to: possibly this may also be found to be the case with seedlings growing on laterite.

ARTIFICIAL REPRODUCTION. So far as experiments show, direct sowing is preferable to transplanting, since there is usually a considerable proportion of failure during transplanting, in spite of precautions. Of the forms of direct sowing tried so far, line sowings kept regularly weeded have proved the most successful, but it is essential that the soil should be kept moist, and where irrigation cannot be carried out, shade is necessary. This can be effected by means of narrow cleared and well-hoed lines under the shade of an overwood or cut through low growth, so as to retain shade and at the same time allow of regular weeding: side shade is of more importance than overhead shade. The seed should be sown early in the rainy season, as soon as it ripens.

Sowings of *Eugenia Jambolana* to fill open grassy or other blanks have been repeatedly tried, but they have almost invariably resulted in failure except along the edge of the surrounding forest, where side shade is obtained from the sun.

For transplanting purposes the greatest success is obtained by sowing in baskets, two or three seeds in each, and retaining the healthiest seedling in each basket. The baskets are kept well watered under moderate shade, and are planted out during the second rains. For forest purposes transplanting should usually be done under shade unless the ground is permanently moist. Roadside trees usually require watering in dry weather for the first year or two. Transplanting from nursery beds requires care, as the seedlings do not stand much exposure of or injury to the roots. Natural seedlings in the forest can be transplanted successfully in moist places or under shade.

SILVICULTURAL TREATMENT. In the forest the tree is ordinarily treated as an accessory species and worked along with other species in coppice coupes or in selection fellings. In private forests on alluvial ground along river-banks in parts of Oudh, pure crops of this species are worked very successfully as simple coppice for the production of poles (see Figs. 211 and 215). The rotation is usually a short one, about 10–15 years, or sometimes less, and judging by the density of the crops the yield must be high: these areas are grazed, but the cattle do not appear to damage the coppice-shoots to any extent.

RATE OF GROWTH. (1) *High forest.* The following statement gives a summary of available girth measurements in high forest sample plots:

Eugenia Jambolana: girth increment in high forest sample plots.

Province.	Forest division.	Locality.	No. of years under measurement.	No. of trees under measurement.	Girth classes.	Mean annual girth increment for period.
					ft.	in.
United Provinces	Dehra Dun	Sherpur forest	4	1	0–1	0·41
	Lansdowne	Chaukhamb	17	2	1½–3	0·70
	,,	Giwain	4	1	1½–3	0·13
	,,	Barswar	4	14	1½–4	0·33
	,,	Jogichaur	4	1	6–8	0·32
	Ramnagar	Mandal	1	3	1½–3	0·40
	,,	S. Patli Dun	19	5	0–3	0·27
	,,	Domanda	19	1	1½–3	0·36
	Haldwani	Silani	11	4	1½–6	0·61
	S. Kheri	Kishanpur	9	1	4–5	0·09
	Gonda	Chandanpur	2	1	0–1½	0·15
	,,	Sakra	2	2	1½–3	0·30
Central Provinces	Balaghat	Raigarh and Baihar ranges	8	2	1–2	0·47
				2	2–3	0·31

The sample plots in question are situated in sal forest, and the rate of growth shown is probably slower than what might be expected on moist alluvial ground near streams.

Ring-countings made in 1905 by Mr. D. A. Thomson in respect of nine trees in the Supa fuel reserves, North Kanara, Bombay, gave the following results:[1]

Eugenia Jambolana: rate of growth in Supa fuel reserves, North Kanara.

Age in years	5	10	15	20	25	30	35	40	45	50	55
Mean diameter (inches)	1·06	2·16	3·26	4·38	5·48	6·58	7·60	8·78	9·82	10·73	11·13
Corresponding girth (inches)	3·2	6·6	10·1	13·5	17·2	20·7	23·9	27·6	31·4	33·8	35·0

A cross-section from the United Provinces in the silvicultural museum at Dehra Dun, measuring 3 ft. 3 in. in girth, had 34 rings, representing a mean annual girth increment of 1·15 in. Measurements in 1907 of eight planted trees, sixteen years old, in the Thapal grant estate, Saharanpur, United Provinces, gave an average girth of 2 ft. 4 in. and an average height of 25·7 ft., which shows that under favourable conditions the growth is fairly fast.

2. *Coppice.* On fertile ground coppice-shoots grow rapidly. On rich alluvium along river banks in Gorakhpur, Oudh, coppice four years old showed an average height of 15 ft. In Nellore, Madras, a height of 6 ft. was attained by coppice-shoots in eight months.[2] Measurements made in 1911 in the Tikri forest, Gonda, United Provinces, showed for an age of two years an average height of 7 ft., as against 7·6 ft. for sal.

The following measurements made in 1886 by Mr. A. F. Broun in the Bullawala sal coppice, Dehra Dun, compare the rate of growth of *Eugenia Jambolana* coppice with that of sal:

Growth of *Eugenia Jambolana* and sal coppice, Bullawala, Dehra Dun.

Age.	Mean girth. *Eugenia.*	Mean girth. Sal.	Mean height. *Eugenia.*	Mean height. Sal.
years.	in.	in.	ft. in.	ft. in.
8	7·5	8·3	16 4	16 2·5
8	6·5	7·1	14 6	13 1·9
9	7·2	8·7	10 0	13 5·5
10	9·0	5·9	14 0	11 10·6

[1] Working Plan for the Supa Fuel Reserves, 1907.

[2] Forest Report, 1909–10.

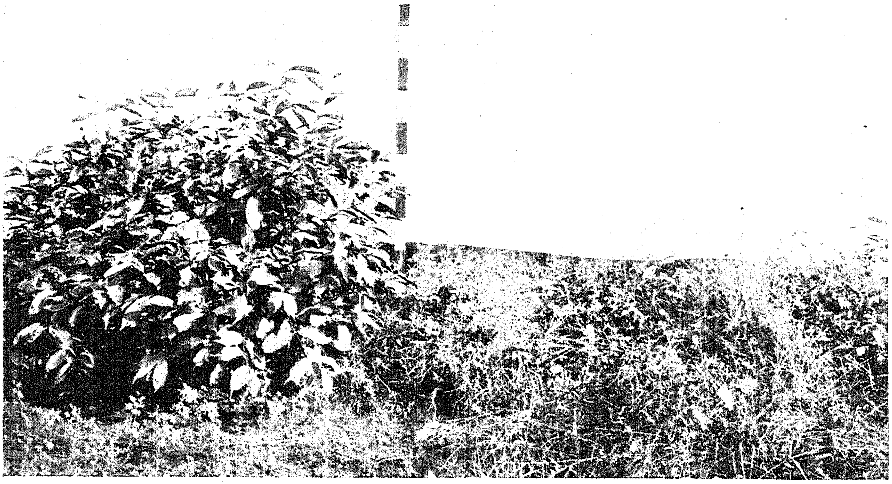

FIG. 213. *Eugenia Jambolana*, plants 13 months old from broadcast sowings, showing beneficial effect of weeding, Dehra Dun: on left of staff, plot regularly weeded contains 88 vigorous seedlings up to 3 ft. 9 in. in height; on right of staff, plot sown at same time and left unweeded contains 23 seedlings up to 1 ft. 3 in. in height struggling through grass and weeds.

FIG. 214. *Eugenia Jambolana*, natural reproduction on soft sandy soil, end of first season, seedlings about 6 in. high, Tirsal forest, Dehra Dun, United Provinces. Note dense mass of seedlings in upper part of picture.

FIG. 215. *Eugenia Jambolana* coppice, 4 years old, 15 ft. high, on alluvial ground along the bank of a stream, Gorakhpur district, United Provinces.

Measurements made in 1910 by Mr. C. M. McCrie in sal coppice in Gorakhpur, United Provinces, showed the following growth for *Eugenia* and sal respectively :

Growth of *Eugenia Jambolana* and sal coppice, Gorakhpur.

	Mean girth.		Mean height.	
Age.	*Eugenia.*	Sal.	*Eugenia.*	Sal.
years.	in.	in.	ft. in.	ft. in.
2	—	—	2 0	3 0
4	2·0	2·0	4 8	7 0
6	3·0	2·9	7 0	10 4
8	3·8	3·8	8 5	13 0
10	4·5	4·8	10 0	15 4

2. **Eugenia operculata,** Roxb. Vern. *Piáman, Rai jáman,* Hind. ; *Kôn thabyè,* Burm.

A moderate-sized evergreen tree with a short bole and spreading branches. Leaves coriaceous, turning red in the cold season. Found in the sub-Himalayan tract, Bihar, Orissa, Assam, Chittagong, and Burma. This is a familiar tree in the sal forests of northern India, particularly on grassy savannahs and blanks, where it is often the first tree to appear, and being fire-resisting and frost-hardy, it establishes itself in such localities and forms a useful nurse to sal, which regenerates well under its protection. In their earlier stages, however, the seedlings are sensitive to frost. In northern India the fruits ripen about August. The growth is slow to moderate. Sample plot measurements in sal forest in the United Provinces give the following results :

Eugenia operculata : girth increment in sample plots, United Provinces.

Forest division.	Locality.	No. of years under measurement.	No. of trees under measurement.	Girth classes.	Mean annual girth increment for period.
				ft.	in.
Lansdowne	Barswar	4	5	$1\frac{1}{2}$–3	0·34
Ramnagar	S. Patli Dun	19	2	0–3	0·17

A cross-section 6 ft. 3 in. in girth, in the silvicultural museum at Dehra Dun, has 83 rings, giving a mean annual girth increment of 0·9 in.

The tree coppices well, and the coppice-shoots sometimes show fairly rapid growth. Measurements of coppice made in 1911 in the Tikri forest, Gonda, United Provinces, showed an average height of 6 ft. in two years, compared with 7 ft. 7 in. for sal ; the average number of shoots per stool was two as compared with 1·8 for sal. Measurements by Mr. C. M. McCrie in 1910 in a coppice coupe three years old in Gorakhpur, United Provinces, showed an average height of 7 ft. 6 in. as against 9 ft. 7 in. for sal. Measurements in 1886 by Mr. A. F. Broun in the Bullawala coppice coupes, Dehra Dun, showed the following growth of *Eugenia operculata* as compared with sal :

Eugenia operculata : growth in coppice coupes, Bullawala, Dehra Dun.

	Mean girth.		Mean height.	
Age.	*Eugenia operculata.*	Sal.	*Eugenia operculata.*	Sal.
years.	in.	in.	ft. in.	ft. in.
8	8·1	8·3	17 4·4	16 2·5
8	6·2	7·1	13 6·6	13 1·9
9	15·2	8·7	17 5·5	13 5·5
10	10·5	5·9	18 3·6	11 10·6

These coupes are subject to occasional severe frosts which damage the sal coppice, and this accounts for the poor growth of the sal in some cases.

3. **Eugenia Jambos,** Linn. Rose apple. Vern. *Guláb jáman*, Hind.

A tree cultivated in many parts of India and Burma for its fruit, which is rather insipid though sweet-scented. According to Brandis it is indigenous in the Malay Archipelago and in Upper Burma (Shwebo district, at 1,000 ft. on stream banks). It has run wild in many places. The handsome flowers, with large yellowish white bunches of stamens, usually appear from February to April. The fruits ripen from June to August, and drop at once; the seeds germinate soon after falling, and large quantities of seedlings may be found under and around the trees during the rainy season, as in the case of *E. Jambolana*. These survive if the locality is sufficiently moist and shady, but if exposed to the sun they die off rapidly. This habit coincides exactly with that of the common form of *E. Jambolana*, and it is possible that on closer study of the various species it may be found to be fairly general in the case of those which grow in moist localities.

2. EUCALYPTUS, L'Héritier.

An Australasian genus consisting of about 140 species, most of which are found in Australia and some in Tasmania, New Guinea, and other islands. The eucalypts are evergreen trees, all more or less aromatic and containing oil-glands in the leaves; the oil distilled from the leaves of some species is of value in medicine. The leaves of young trees, of young coppice-shoots, and of shoots sent out after injury by fire or otherwise, are generally opposite, sessile, and horizontal, and are often of a different shape from the normal leaves of the adult tree; the latter are usually alternate, petiolate, and hang vertically. The flowers are white or red, and the flower-buds have the calyx-tube covered with a lid or operculum which falls off when the flowers open. The fruit is a woody capsule, consisting of the hard calyx-tube and containing numerous small seeds, a considerable proportion of which are usually unfertile.

The eucalypts contain several of the most important timber trees of the Australian continent, where they form large tracts of forest, some growing pure and others mixed. Some of them reach gigantic size, and are among the largest trees in the world, specimens of the blue gum (*E. Globulus*, Labill.) and peppermint gum (*E. regnans*, F. v. M., formerly included under *E. amygdalina*, Labill.) having been stated to reach a height of over 400 ft.

Introduction into foreign countries. The eucalypts appear first to have attracted attention outside their natural home in the early part of the nineteenth century, when seed began to be introduced into southern Europe, and the trees, probably for the most part *E. Globulus*, began to be cultivated, first for ornament or as curiosities, and later, when their rapid growth and economic importance began to be realized, in plantations. Since then eucalypts have been extensively planted in the Mediterranean region, in California, Florida, Hawaii, and several other parts of the western hemisphere, in South Africa, and in other sub-tropical and warm temperate regions throughout the globe.

Introduction into and cultivation in India. The introduction of

eucalypts into India probably dates from 1843, when a few trees were planted experimentally in the Nilgiris mainly with the object of finding some species capable of yielding regular and plentiful supplies of fuel: regular plantations, chiefly of *E. Globulus*, were commenced in these hills in 1856, and have been extended subsequently on a large scale. Numerous species have since been tried under all sorts of climatic and other conditions in many parts of India and Burma, both in the hills and on the plains. Some details of the results attained in different localities are given below, but it may be said generally that some species or other of eucalyptus has been found which is suited to almost any climate in India with the possible exception of: (1) very moist tropical regions, where the seedlings damp off in spite of all precautions; and (2) elevations above the winter snow-line, where snow-break is to be feared. It is, however, possible that species may yet be found which will grow well in localities where eucalypts have failed hitherto, for although several species have been proved to thrive well in India under given conditions, the introduction of a large number is as yet in the initial stage of experiment or has not yet been attempted.

The extension of eucalyptus cultivation in India has its advocates and its opponents. The former urge the great utility of these trees in supplying fast-growing timber and fuel as well as oil, tannin, and other products, their swamp-draining capacity and their direct anti-malarial value, though from a medical point of view the last-named quality appears to be problematical. The latter maintain that the extension of eucalyptus cultivation in India has gone far enough, that the trees are monotonous, and that in regions where they are capable of growing it is possible to grow indigenous trees which furnish better timber and are superior in every way except so far as rapidity of growth is concerned. There is something to be said on both sides. It is true that as timber trees the eucalypts have not come up to expectations in India, but that is no reason for believing that some good timber species may not yet be found which will be capable of profitable cultivation. On the other hand, so far as fuel production goes, the rapidity of growth and the volume-production of the eucalypts in places where they do thrive far exceed anything attainable by indigenous species. The blue gum has conferred an inestimable boon on the Nilgiris, and those who complain of the monotony of the eucalypts which dominate the landscape on the Nilgiri plateau should remember that these trees saved a fuel famine in the middle of last century, while in Ootacamund and the adjoining stations they now yield plentiful supplies of fuel, obtainable at far cheaper rates than is the case in any other hill station in India. Where large supplies of quick-growing and therefore cheap fuel are required, there seems to be every reason for the extension of eucalyptus plantations in India in places where these trees will grow well and furnish higher yields than indigenous species; while, again, the experimental introduction of little-known or new species, which has been proceeding for several years past, is all to the good, since it tends towards a solution of the question of cheap supplies of fuel and possibly of timber. Provided, therefore, the extension of eucalyptus cultivation in India is confined to cases where it is likely to be of distinct advantage, and does not involve the clearing of valuable indigenous timber species, there is much to be said in favour of it.

Much experimental work has been carried out in the past, and continues to be carried out, in the cultivation of eucalyptus in India, but in spite of this the records of results are in most cases disappointing, and are often unreliable. Fruitful sources of error are the wrong naming of seeds, the inadvertent mixing of seeds of different species, the interchanging of labels of plants in different stages, as well as errors and omissions in maintaining the records. Again, it frequently happens that a species grows well for a few years and then fails; it is favourably reported on for some years and the record then ceases, though the plant has by this time acquired an undeserved reputation, and is wrongly recorded as a success. It is therefore of little use judging of the suitability of a species for a given locality until it has reached reasonable dimensions and shown its adaptability to its new environment. Mistakes in identification are very common, and have been the cause of a good deal of confusion in the past. For the correct identification of the eucalypts, botanical specimens should be as complete as possible, and should ordinarily include primordial as well as adult leaves, flowers, fruits, and bark: as these are not all obtainable at the same time, great care is necessary to ensure that the specimens are all collected from the same tree.

Numerous failures in the past have been due to the fact that trees from the temperate regions of Australasia have been repeatedly tried in the hotter parts of India, while those from the tropical and other warm regions of that continent have been tried at cool elevations in the hills. Generally speaking it may be laid down that for low elevations in India, if any species is to have a reasonable chance of succeeding it must be obtained from the tropical and warm parts of Queensland and adjacent northern regions, where also are found such well-known Indian trees as *Bombax malabaricum*, *Eugenia Jambolana*, *Barringtonia racemosa*, *Alstonia scholaris*, *Mallotus philippinensis*, *Trema orientalis*, *Ficus glomerata*, and *Casuarina equisetifolia*. On the other hand, species from Tasmania and the southern parts of Australia only are likely to be successful at the higher elevations in India. To quote one example: the blue gum (*E. Globulus*), a tree of Tasmania and the south-eastern parts of Australia, has been tried time and again at low elevations in India, but has always failed signally, whereas at the higher elevations in the Nilgiris it has been a remarkable success.

The results attained hitherto in different parts of India, so far as records are available, are of some interest, and may prove to be useful as a guide towards the selection of species for further experiment.

1. *The Nilgiris.* The introduction of eucalypts in 1843, and the formation of plantations from 1856 onwards, have already been alluded to. In 1914 the total area of Government eucalyptus plantations, either pure or mixed with acacia, amounted to 1,089 acres, in addition to which there are numerous privately owned plantations. Fuel from these is supplied at extremely cheap rates. The altitude of the plantations varies from 5,000 to 8,300 ft. The principal rock is a fine-grained gneiss decomposing into a red clay: there is a marked absence of lime in the soil.

The climate of the Nilgiris is cool, equable, and moist, with a well-distributed rainfall of about 50 to 80 in. The winter is on the whole mild, with only occasional frosts of more than slight intensity, and these are of short

duration; snow is unknown. The following climatological statistics may be quoted:

Climatological statistics for the Nilgiris.

Station.	Shade temperature (degrees Fahr.). Maximum. Absolute.	Average.	Minimum. Absolute.	Average.	Normal rainfall (inches). Jan.–Mar.	Apr.–May.	June–Sept. (SW. monsoon).	Oct.–Dec. (NE. monsoon).	Total for year.
Ootacamund (7,327 ft.)	..	75	..	35	2·46	9·70	24·76	14·03	50·95
Coonoor (6,200 ft.)	..	..	..	..	8·17	8·82	16·68	32·09	65·76
Wellington (6,200 ft.)	83·4	81	24·7	36	..	..	..	..	51·09

The species far more extensively planted than any other is *E. Globulus*, which grows very rapidly and thrives admirably. Many other species, however, have been planted, not only in plantations but also in private gardens and along roadsides, while there are many different species in the Government gardens at Ootacamund and in Sim's Park at Coonoor. The identity of many of these was obscure until, in 1912 and subsequently, Mr. R. Bourne made a careful investigation into the question, and with the aid of specimens collected on the spot succeeded in establishing the identity of no fewer than 36 species. After *E. Globulus* by far the commonest species in the Government plantations are *E. obliqua* and *E. Sieberiana*. Except *E. Globulus* the only two species which have attained large dimensions are *E. obliqua* and *E. eugenioides*, to which may be added occasional large specimens of *E. viminalis*. The following is a complete list of species which Mr. Bourne has succeeded in identifying in the Nilgiris: *E. acmenoides*, Schauer, *E. amygdalina*, Labill., *E. botryoides*, Sm., *E. calophylla*, Brown, *E. capitellata*, Sm., *E. cornuta*, Labill., *E. corymbosa*, Sm., *E. crebra*, F. v. M., *E. eugenioides*, Sieber, *E. ficifolia*, F. v. M., *E. foecunda*, Schauer, *E. Globulus*, Labill., *E. Gunnii*, Hook., *E. hemiphloia*, F. v. M., *E. Leucoxylon*, F. v. M., *E. longifolia*, Link and Otto, *E. macrorrhyncha*, F. v. M., *E. maculata*, Hook., var. *citriodora*, Bailey, *E. microcorys*, F. v. M., *E. miniata*, Cunn., *E. obliqua*, L'Hérit., *E. paniculata*, Sm., *E. ptychocarpa*, F. v. M., *E. pilularis*, Sm., *E. pulverulenta*, Sims., *E. punctata*, DC., *E. redunca*, Schauer, *E. resinifera*, Sm., *E. robusta*, Sm., *E. rostrata*, Schleich, *E. saligna*, Sm., *E. siderophloia*, Benth., *E. Sieberiana*, F. v. M., *E. Stuartiana*, F. v. M., *E. tereticornis*, Sm., *E. viminalis*, Labill.

Trials were commenced in 1910 to ascertain if any good timber-yielding species will succeed in the Nilgiris, and for this purpose small experimental plantations were formed at three different elevations, namely 6,700, 7,300, and 8,300 ft. The species tried were *E. acmenoides*, Schauer, *E. crebra*, F. v. M., *E. eugenioides*, Sieber, *E. hemiphloia*, F. v. M., *E. paniculata*, Sm., *E. pilularis*, Sm., *E. punctata*, DC., and *E. siderophloia*, Benth. There was some difficulty in raising the young plants, which proved tender in the early stages, and had to be reared under forcing frames. When once put out they proved more hardy, but required protection against frost, for which purpose they were surrounded with coverings of bracken. The species which have done best so far are *E. punctata*, *E. acmenoides*, and *E. pilularis*. The least promising is *E. hemiphloia*.

2. *Indian Peninsula*. Except in the Nilgiris there is little reliable informa-

tion regarding the results of planting eucalypts in the Indian Peninsula. Probably the most successful species so far tried at low elevations is *E. tereticornis*, which grows well even at Bombay; *E. rostrata* also does well at low elevations, and is grown at Poona and elsewhere. Attempts made about 1874–6 at Saugor in the Central Provinces, to grow certain species, including *E. cornuta*, *E. Globulus*, *E. marginata*, *E. obliqua*, *E. rostrata*, *E. Sideroxylon*, and *E. viminalis*, resulted in failure. *E. Globulus* was tried in 1909 in coast sand in the Madras Presidency, but needless to say the result was a failure. In the same year *E. marginata*, *E. resinifera*, and *E. rostrata* were sown in the Sanyasimalai plantation in North Salem at an elevation of 4,000 ft.; the seedlings throve the first year, but no subsequent information is available. Eleven different species were tried at Mercara in Coorg in 1913; those which proved the most successful during the first few years were *E. maculata*, *E. pilularis*, *E. punctata*, *E. goniocalyx*, *E. saligna*, and *E. resinifera*. Plants of *E. maculata* three years old had a maximum height of 21 ft. and a maximum girth of 7 in.

3. *Himalaya*. Eucalypts have been grown in various parts of the Himalaya for many years, but at elevations where there is any appreciable snowfall in winter they have suffered so severely from snow-break that they are now recognized to be unsuitable for planting except at the lower elevations. *E. Globulus* is probably the species which has been planted most extensively, and it has grown well except for liability to snow-break; *E. Sideroxylon* is reported to have done well in the Kumaun hills. Mr. R. N. Parker notes that at Abbottabad (elevation 4,000 ft.), where eucalypts are extensively grown, the species seen are *E. tereticornis*, *E. rostrata*, *E. Sideroxylon*, *E. maculata* var. *citriodora*, and *E. Globulus*.[1] Prior to the abnormal frost of 1905 *E. Globulus* was far commoner than it is now, but all the trees were badly injured and many were killed outright in that year. At present *E. tereticornis* is by far the commonest species in that station: there are also several specimens of *E. Sideroxylon*, and one each of *E. rostrata* and *E. maculata* var. *citriodora*, dating from before 1905.

Experiments in the cultivation of eucalyptus in the Simla hills have been in progress for some years past, the most complete of these dating from 1909, when small experimental plots were established at various elevations along the Kalka–Simla railway and in the neighbourhood of Simla itself. The cultivation was carried out by means of direct sowings on roughly prepared ground, no watering being done. So far the following have been found to succeed, to some extent at least, at different elevations:

(*a*) Under 4,000 ft.: *E. calophylla*, R. Br.*, *E. cornuta*, Labill., *E. corynocalyx*, F. v. M., *E. eximia*, Schauer*, *E. gomphocephala*, DC., *E. goniocalyx*, F. v. M., *E. Gunnii*, Hook., *E. hemiphloia*, F. v. M., *E. Leucoxylon*, F. v. M.*, *E. longifolia*, Link and Otto*, *E. Maideni*, F. v. M., *E. melliodora*, A. Cunn., *E. microcorys*, F. v. M., *E. paniculata*, Sm.*, *E. punctata*, DC., *E. resinifera*, Sm., *E. rostrata*, Schlecht*, *E. rudis*, Endl., *E. Stuartiana*, F. v. M., *E. tereticornis*, Sm.*

(*b*) 4,000–6,000 ft.: *E. amygdalina*, Labill., *E. Cambagei*, Deane and Maiden*, *E. coriacea*, A. Cunn., *E. corynocalyx*, F. v. M., *E. crebra*, F. v. M.,

[1] Ind. Forester, xxxix (1913), p. 81.

E. eugenioides, Sieb., *E. eximia*, Schauer*, *E. Globulus*, Labill.*, *E. gomphocephala*, DC., *E. Gunnii*, Hook.*, *E. hemiphloia*, F. v. M., *E. longifolia*, Link and Otto*, *E. Maideni*, F. v. M.*, *E. melliodora*, A. Cunn., *E. Planchoniana*, F. v. M., *E. regnans*, F. v. M., *E. rudis*, Endl., *E. saligna*, Sm., *E. Sideroxylon*, A. Cunn., *E. Stuartiana*, F. v. M.*, *E. tereticornis*, Sm., *E. viminalis*, Labill.*

(*c*) 6,000–7,000 ft. : *E. Cambagei*, Deane and Maiden, *E. corymbosa*, Sm., *E. corynocalyx*, F. v. M., *E. crebra*, F. v. M., *E. Globulus*, Labill., *E. Gunnii*, Hook.*, *E. hemiphloia*, F. v. M., *E. Maideni*, F. v. M.*, *E. Stuartiana*, F. v. M.*, *E. viminalis*, Labill.*

(*d*) Over 7,000 ft. : *E. corymbosa*, Sm., *E. corynocalyx*, F. v. M., *E. crebra*, F. v. M., *E. melliodora*, A. Cunn., *E. saligna*, Sm.

Those marked with an asterisk have so far proved the most successful. Above 5,000 ft. the results have not been nearly so satisfactory as they have below that elevation, though this is ascribed more to poverty of soil than to elevation. Species which have so far proved unsuitable for introduction on a large scale are *E. haemastoma*, Sm., *E. macrorrhyncha*, F. v. M., *E. Muelleriana*, Howett, *E. obliqua*, L'Hérit., *E. pauciflora*, Sieb., *E. pilularis*, Sm., *E. piperita*, Sm., *E. Sieberiana*, F. v. M.

Further experiments are in progress in the Simla hills with numerous other species, and these may be expected to yield definite results in due course.

4. *Sub-Himalayan tract and plains of northern India.* Eucalypts were first introduced into northern India about 1860, and numerous species have been tried. The reports of the Government gardens at Lucknow, Lahore, and Saharanpur contain the results of various trials from time to time. In the Changa Manga irrigated plantation near Lahore various species were introduced many years ago, while more recently experiments on a considerable scale have been carried out there and in the Kot Lakhpat plantation.

Mr. R. N. Parker [1] enumerates the following species found growing on the Punjab plains, which he has been able to identify with tolerable certainty, though he admits that the list is by no means complete :

E. maculata, Hook., var. *citriodora*, Bailey. Less common than the following two in the Punjab, but the commonest species in Saharanpur and Dehra Dun.

E. tereticornis, Sm. This and the next are the commonest species in the Punjab, and have given the best results where extensive trials have been made. Almost the only species in the Rawalpindi and Hazara districts. Succeeds well in the Hoshiarpur district. Not common at Saharanpur and Dehra Dun.

E. rostrata, Schl. Very common on the Punjab plains ; seldom seen in Rawalpindi and Hazara. Does well at Saharanpur.

E. crebra, F. v. M. Occasionally seen in Lahore, Amritsar, Kapurthala, Changa Manga, and Saharanpur.

E. melanophloia, F. v. M. Grown in Lahore, Changa Manga, Agra, and Saharanpur.

E. saligna, Sm. Grows well at Amritsar and Saharanpur.

E. robusta, Sm. Occasionally grown in Lahore, Kapurthala, Saharanpur, and Agra.

[1] *loc. cit.*

E. siderophloia, Benth. One specimen in Changa Manga doing well.

E. Sideroxylon, A. Cunn. Several in Changa Manga, not doing very well.

The first three of the above species are by far the commonest grown in the plains and sub-Himalayan tract.

According to Mr. Parker the following species have been sufficiently tried to show that they are quite unsuitable for planting on the plains :

E. amygdalina, Labill., *E. capitellata*, Sm., *E. coccifera*, Hook. f., *E. coriacea*, A. Cunn. (*E. pauciflora*, Sieb.), *E. corymbosa*, Sm., *E. Globulus*, Labill., *E. goniocalyx*, F. v. M., *E. Gunnii*, Hook. f., *E. haemastoma*, Sm., *E. macrorrhynca*, F. v. M., *E. marginata*, Sm., *E. obliqua*, L'Hérit., *E. pilularis*, Sm., *E. piperita*, Sm., *E. resinifera*, Sm., *E. Sieberiana*, F. v. M., *E. Stuartiana*, F. v. M., *E. urnigera*, Hook. f., *E. viminalis*, Labill., *E. virgata*, Sieb. (*E. stricta*, Sieb.).

The following species appear to be unlikely to thrive on the plains, though evidence is not yet conclusive :

E. acmenoides, Schau., *E. alpina*, Lindl., *E. Andrewsi*, Maiden, *E. Baileyana*, F. v. M., *E. calophylla*, R. Br., *E. cinerea*, F. v. M., *E. corynocalyx*, F. v. M., *E. delegatensis*, R. T. Baker, *E. dives*, Schau., *E. eugenioides*, Sieb., *E. eximia*, Schau., *E. ficifolia*, F. v. M., *E. longifolia*, Link and Otto, *E. Luehmanniana*, F. v. M., *E. Macarthuri*, Deane and Maiden., *E. macrandra*, F. v. M., *E. macrocarpa*, Hook., *E. Muelleriana*, Howett, *E. occidentalis*, Endl., *E. obcordata*, Turcz. (*E. Platypus*, Hook.), *E. Planchoniana*, F. v. M., *E. regnans*, F. v. M., *E. rubida*, Deane and Maiden, *E. Smithii*, R. T. Baker, *E. stellulata*, Sieb., *E. trachyphloia*, F. v. M., *E. umbra*, R. T. Baker.

Many other species are under trial. At Lahore, among species which have shown promise during the first few years are *E. gomphocephala*, DC., *E. hemiphloia*, F. v. M., *E. melanophloia*, F. v. M., *E. melliodora*, A. Cunn., and *E. rudis*, Endl. The last named has shown extraordinary growth on poor saline soil, and appears to be well suited for such ground. *E. Kirtoniana*, F. v. M., does well if it gets sufficient water. At Saharanpur the most successful so far, apart from those already mentioned, are *E. microcorys*, F. v. M., *E. obliqua*, L'Hérit., *E. paniculata*, Sm., and *E. rudis*, Endl. The following, recently grown at Dehra Dun, are well established : *E. bicolor*, A. Cunn., *E. botryoides*, Sm., *E. microcorys*, F. v. M., *E. patentinervis*, R. T. Baker, *E. rostrata*, Schl., *E. saligna*, Sm., *E. Sideroxylon*, A. Cunn. ; of these *E. bicolor*, *E. botryoides*, and *E. Sideroxylon* are regarded as failures at Saharanpur.

The following climatological statistics for plains and low-level stations in northern India give some indication of the conditions under which the above-mentioned species have been tried :

Climatological statistics for some plains and low-level stations in northern India.

Station.	Shade temperature (prior to 1903). Absolute maximum. degrees F.	Absolute minimum. degrees F.	Normal rainfall. in.	
Lahore	120·3	29·2	20	The great bulk of the rain falls during the SW. monsoon from July to September; the remainder of the year is dry except for occasional showers or bursts of rain.
Saharanpur	116	30	38	
Lucknow	119	30	38	
Agra	120	30	26	
Dehra Dun	111	33·9	85	

5. *Assam.* *E. Globulus* thrives at Shillong, showing rapid growth and attaining very fair dimensions.

6. *Burma.* Eucalypts have been tried from time to time in various parts of Burma. At Maymyo (elevation 3,500 ft.) planting was commenced about the year 1893; the species which has proved most successful there is *E. rostrata*, though *E. amygdalina* and *E. maculata* var. *citriodora* have also done well, and *E. resinifera* fairly well. These species are likely to do well on the Shan States plateau should plantations be required there. There is a fine avenue in the Maymyo bazaar consisting chiefly of *E. rostrata*. *E. Globulus* has proved a failure at Maymyo, but has succeeded in the hills of the Ruby Mines district. The species which has done best at low elevations is *E. viminalis*, which has proved hardy. *E. cornuta* was reported in 1911–12 to be growing well in a rubber plantation at Kwanhla in the Amherst township.

7. *Andamans.* Seventeen species were tried in the Andamans in 1914, but after the first year the only species showing any promise were *E. resinifera*, *E. robusta*, *E. rostrata*, and *E. tereticornis*. Two species, namely *E. botryoides* and *E. robusta*, were tried in mangrove swamps, but were unable to stand the salt water.

Silvicultural characters. Eucalypts, as a rule, are intolerant of shade, though many species tend to branch low if grown in isolated positions, and in early youth seedlings endure a little shade for a time. Many species coppice well, but the blue gum (*E. Globulus*) is probably the most vigorous of all the better known species in this respect. The root-system is usually of a spreading type, the roots penetrating for a considerable distance in search of moisture; superficial spreading roots are common. Eucalypts are generally speaking wind-firm, but many species are liable to become bent, gnarled, and stunted in exposed situations. Species tried at the higher elevations in the Himalaya have been found very liable to snow-break. Fire does little damage to older trees with thick persistent bark, but young trees and those with thin or deciduous bark suffer severely: those whose bark exfoliates in long dry strips, like *E. Globulus*, suffer much damage, the fire ascending up the loose bark into the crowns. Most species have good power of recovery from damage by fire. Injured trees produce shoots with primordial leaves, and a blue gum plantation which has recently been burnt presents a silvery-blue appearance, owing to the production of these shoots. The most aromatic eucalypts are not readily browsed by cattle; two species particularly susceptible to this form of damage are *E. corynocalyx*, whose leaves have a sweetish taste, and *E. Gunnii*, whose leaves are not strongly aromatic. Plantations of young trees near Dehra Dun have suffered much through rubbing by deer, the aromatic bark attracting these animals; where deer are prevalent, fencing may therefore be necessary. In the Changa Manga plantation in the Lahore district, seedlings are browsed down by *nilgai* in the winter, and when the plants are out of reach of browsing these animals gnaw the bark.

The requirements of the various species as regards soil and climate vary considerably. Some details are given under the individual species described below, but so far as Indian conditions go our knowledge is confined to a comparatively small number of species which have been tried in different localities. Much experimental work remains to be done in discovering species suitable

for the diverse climates and types of soil met with in India, for experience has shown that it is most unsafe to predict the behaviour of a newly tried species in India, even though its requirements are well understood in its natural home. Generally speaking, most if not all eucalypts grow best on deep fresh soil with a fair amount of subsoil moisture; many, however, accommodate themselves to poor dry soils, swampy ground, exposed situations, high altitudes, or other conditions unfavourable to their best development, and here they often assume a stunted or misshapen form or display special characteristics amounting to sub-specific variation, for example in the form of the bark, the shape and size of the leaves, or the amount of essential oil contained in them.

The following are some examples of species whose requirements are tolerably well known:

Suitable for wet ground: *E. rostrata* (probably the best for swampy ground), *E. robusta*, and to some extent *E. botryoides*, *E. Globulus*, and *E. tereticornis*.

Suitable for dry, poor soil: *E. corynocalyx*, *E. resinifera*, *E. siderophloia*, *E. Sieberiana*.

Exacting as to soil: *E. Globulus*, *E. pilularis*.

Not exacting as to soil (i. e. will tolerate dry as well as unduly moist soils): *E. amygdalina*, *E. cornuta*, *E. resinifera*, *E. robusta*, *E. rudis*, *E. Sideroxylon*, *E. viminalis*.

Suitable for saline soils: *E. rudis*.

Frost-resistant: *E. coriacea*, *E. Gunnii*, *E. resinifera*, *E. rostrata*, *E. siderophloia*, *E. tereticornis*, *E. viminalis*.

Frost-tender: *E. calophylla*, *E. maculata* var. *citriodora*.

The following list of relative frost-hardiness of different species of *Eucalyptus* has been drawn up by Mr. E. N. Munns as a result of observations during an exceptional period of low temperature in South California:[1]

Very resistant to low temperatures: *E. viminalis*, *E. polyanthema*, *E. Gunnii*, *E. regnans*, *E. crebra*.

Resistant to low temperatures: *E. tereticornis*, *E. rostrata*, *E. Globulus*, *E. coriacea*, *E. resinifera*, *E. corynocalyx*, *E. robusta*, *E. goniocalyx*.

Frost-sensitive, but capable of recovering from injury: *E. Sideroxylon*, *E. Stuartiana*, *E. citriodora*, *E. longifolia*, *E. amygdalina*, *E. saligna*.

Very frost-sensitive: *E. rudis*, *E. corymbosa*, *E. Leucoxylon*, *E. cornuta*, *E. diversicolor*, *E. calophylla*.

Drought-resistant: *E. corynocalyx*, *E. resinifera*.

Drought-tender: *E. Globulus*, *E. maculata* var. *citriodora*, *E. obliqua*, *E. saligna*.

NATURAL REPRODUCTION. So far as India is concerned, the question of natural reproduction from seed is at present of no consequence. To a limited extent natural seedlings have been springing up in and around the blue gum plantations of the Nilgiris for some years past, and the essential conditions appear to be bare soil free of weeds and sufficient light. In Australia it is generally recognized that natural reproduction can be secured without much difficulty by cutting the undergrowth, passing fire over the area, and thereafter strictly protecting from fire and in the first few years from grazing; these methods usually result in a good crop of natural seedlings, from seed

[1] Journal of Forestry, xvi (April 1918), p. 412.

lying dormant or falling subsequent to the fire, wherever there is sufficient light for their development.

Artificial reproduction. The artificial raising of eucalypts requires a considerable amount of care: the seeds are small and are easily washed away by rain, while the young seedlings of many species are sensitive to drought or frost and for some little time after germination are very liable to damp off with excessive moisture.

Direct sowings are less commonly employed than transplanting, but *E. crebra* was sown with success at Dehra Dun on alluvial ground in lines with the aid of field crops, a cleared strip 3 ft. wide in which the eucalypts were sown being left unsown with the field crop; two lines of eucalypts $1\frac{1}{2}$ ft. apart were sown, with a line of sal between them, the object of the former being to act as a protection to the sal against frost and drought. The field crop employed was the lesser millet or *mandwa* (*Eleusine coracana*), which was sown in June and reaped in October, and the eucalyptus was sown in August, $1\frac{1}{2}$ oz. of seed being used for sowing the double line 74 ft. long. The eucalypt seedlings died off in quantity in the first dry season, but a sufficient number survived to produce thickly stocked lines, the dominant plants reaching a height of 5–6 ft. in eighteen months; they were then much in need of thinning out, and their subsequent development was poor owing to their congested state. This experiment is not conclusive, but this method of sowing is worth further trial where seed is plentiful. Experimental broadcast sowings have been carried out since 1909 in small patches in the Simla hills, and the results have been noted on pp. 560 and 561; more recently sowings on a larger scale have been tried, but the results have not proved successful.

Nursery treatment. The methods of raising eucalypt seedlings in the nursery vary considerably, and local experience alone can decide which method to adopt in any particular case. Experience has shown that the best time for sowing the seed in most parts of India, both in the hills and on the plains, is early spring, about February–March or even as early as January in the hills; this enables the seedlings to reach a size large enough for planting out at the beginning of the rainy season. The cheapest method of raising seedlings is to rear them in seed-beds, which should be well raised and should consist of a mixture of fine leaf-mould and sand. The surface having been well smoothed and moderately, not excessively, watered, the seed is sown broadcast on the surface and lightly covered with a layer of fine earth. The seed-beds should be kept moist with a fine spray until germination begins: from the commencement the beds should be protected by a covering, raised about 12 in. above them, of thatch or other material impervious enough to prevent rain from dripping through, these screens being removed in dull cloudy weather and replaced to protect the beds and seedlings from sun, frost, or heavy rain. The seedlings require a fair amount of water, but excess of moisture causes damping off. The beds should never be flooded; watering should be done frequently but sparingly with a fine spray.

Flat boxes about 4 or 5 in. deep are in many ways preferable to seed-beds, and for new species as yet untried or of which only a limited quantity of seed is available they should certainly be adopted. The bottoms of the boxes should have a number of small holes bored in them for drainage purposes,

and otherwise the same precautions as regards soil, watering, and protection should be employed. An open shed is useful for protecting the boxes of seedlings during heavy rain and frosty weather or in the heat of the day. One special advantage of seed-boxes is that they can be protected against ants, which carry off the seeds, and white ants, which destroy the roots of young seedlings: the boxes may be isolated by placing them on stones wrapped in cloth soaked with kerosene oil or on stands the legs of which rest in tins of water. In place of boxes, kerosene tins cut in half, with holes punctured on the under side, may be employed.

Whether raised in seed-beds or in boxes, the seedlings on attaining a height of 2 to 4 in. should be pricked out 2 to 3 in. apart, either in nursery-beds or in boxes, and shaded for the first two or three days. Pricking out requires much care, as the seedlings are sensitive to any damage to stem or roots. On attaining a height of about 6 in. they may require pricking out again, or what is preferable, they may be planted individually in baskets or pots made of stiff paper about 8 or 9 in. deep, or in bamboo tubes open at either end, the lower end being stopped up with grass or other material; in transplanting the baskets or pots are buried bodily, the bottoms having been broken open, while in the case of the bamboo tubes the plant is forced down through the tube into the planting hole, the tube being removed. In this way there is no disturbance of the roots during transplanting. Clay pots at least 7 in. deep may also be employed, the seedlings being carefully removed from them, with the earth intact, for planting purposes. In the Nilgiris the system of mossing is sometimes adopted, the roots of the seedling, enclosed in a ball of earth, being wrapped round with moss with the object of retaining moisture; the mossed plants are placed on the ground under partial shade, regularly watered, and shifted slightly every few days to prevent the roots from fixing themselves in the ground.

Where baskets, pots, &c., are employed, the preliminary pricking out is sometimes dispensed with, the seedlings being transferred to them straight from the seed-beds or boxes. For planting out purposes where seedlings have been pricked out in boxes the boxes of seedlings should, if possible, be conveyed to the planting site and the seedlings should be removed from the boxes by means of a trowel, with as little disturbance of the earth round the roots as possible. If transplanting is to be carried out in a dry situation the plants should be gradually hardened in the nursery by giving them more and more sun and less and less water.

Planting and spacing. In India the best time for planting is about the beginning of the rainy season, and for forest purposes seedlings about 12 in. in height are the most suitable. Winter planting has been tried in the Himalaya, but the results were less successful than in the case of monsoon planting. It is advantageous to dig the pits two or three months beforehand and expose the soil; in low-lying or swampy ground it may be found advisable to plant on slightly raised mounds.

The question of spacing is somewhat debatable, and probably the only definite conclusions arrived at so far in India are in respect of the blue gum plantations in the Nilgiris, where in the earlier years various spacings from 6 ft. by 6 ft. to 9 ft. by 9 ft. were adopted. At first opinions varied as to

the results likely to be attained, but there is now no doubt whatever that a spacing of 9 ft. by 9 ft. is preferable to one of 6 ft. by 6 ft., and that there is no occasion to plant closer than 8 ft. by 8 ft.; these wider spacings not only give equally good, if not better results, but also reduce the cost of formation considerably. As regards other species and conditions, accurate information is wanting as to the best spacings to adopt in India. Generally speaking, however, wide spacings, say 8 ft. by 8 ft. to 10 ft. by 10 ft., are indicated on good soils, and for species which grow vigorously and tend to form clean boles, while closer spacings are necessary on poor soils and for species which develop more slowly and tend to branch low. It is doubtful if a spacing of less than 6 ft. by 6 ft. is ever indicated in India if a plantation is to prove profitable.

Subsequent tending. For the first year, or sometimes two years, it may be necessary to protect the young plants from frost by means of cowls of grass or bracken. Hand watering is not ordinarily practicable under forest conditions on a large scale; most eucalypts, however, respond to irrigation. Thinnings first become necessary as a rule from the sixth to the tenth year, and the effect of regular thinnings on the yield and on the subsequent development of the crop is most marked.

System of working. So far as India is concerned, the Nilgiri blue gum plantations are the only ones which have as yet been worked regularly, the system adopted being for the most part simple coppice for the production of fuel: hitherto the rotation adopted has been ten years, but this has recently been increased to fifteen years. A few of the less accessible plantations have been left as high forest to be felled later, and as far as can be foreseen the best method of regeneration will be by clear-felling and replanting. Coppice-with-standards has been tried in the Nilgiris, but the results were unsatisfactory owing to the poor growth of the coppice, and this system has been abandoned in the Government plantations. Some further details regarding the working of the Nilgiri plantations will be found below under *E. Globulus*.

Particulars regarding species. Information regarding most of the species which have hitherto been tried in India is given below. Particulars as to the characters and occurrence of these trees in their natural home have been taken mainly from von Mueller's *Eucalyptographia*, Maiden's *Critical Revision of the Genus Eucalyptus* and *Flora of New South Wales*, Baker and Smith's *Research on the Eucalypts*, Bentham's *Flora Australiensis*, and Bailey's *Queensland Woods*.

Species (in alphabetical order) 1. *E. acmenoides*, Schauer; 2. *E. alpina*, Lindl.; 3. *E. amygdalina*, Labill.; 4. *E. Andrewsi*, Maiden; 5. *E. Baileyana*, F. v. M.; 6. *E. bicolor*, A. Cunn.; 7. *E. botryoides*, Smith; 8. *E. calophylla*, R. Br.; 9. *E. Cambagei*, Deane and Maiden; 10. *E. capitellata*, Smith; 11. *E. cinerea*, F. v. M.; [*E. citriodora*, Hook., see 36. *E. maculata*, Hook.; *E. coccifera*, Hook. f., see 3. *E. amygdalina*, Labill.]; 12. *E. coriacea*, A. Cunn.; 13. *E. cornuta*, Labill.; 14. *E. corymbosa*, Smith; 15. *E. corynocalyx*, F. v. M.; 16. *E. crebra*, F. v. M.; 17. *E. delegatensis*, R. T. Baker; 18. *E. dives*, Schauer; 19. *E. eugenioides*, Sieber; 20. *E. eximia*, Schauer; 21. *E. ficifolia*, F. v. M.; 22. *E. foecunda*, Schauer; 23. *E. Globulus*, Labill.; 24. *E. gomphocephala*, DC.; 25. *E. goniocalyx*, F. v. M.; 26. *E. Gunnii*, Hook.; 27. *E.*

haemastoma, Smith; 28. *E. hemiphloia*, F. v. M.; 29. *E. Kirtoniana*, F. v. M.; 30. *E. Leucoxylon*, F. v. M.; 31. *E. longifolia*, Link and Otto; 32. *E. macrandra*, F. v. M.; 33. *E. Macarthuri*, Deane and Maiden; 34. *E. macrocarpa*, Hook.; 35. *E. macrorrhyncha*, F. v. M.; 36. *E. maculata*, Hook.; 37. *E. Maideni*, F. v. M.; 38. *E. marginata*, Smith; 39. *E. melanophloia*, F. v. M.; 40. *E. melliodora*, A. Cunn.; 41. *E. microcorys*, F. v. M.; 42. *E. miniata*, Cunn.; 43. *E. Muelleriana*, Howett; 44. *E. obcordata*, Turcz.; 45. *E. obliqua*, L'Hérit.; [*E. obtusifolia*, DC., see 74. *E. virgata*, Sieb.]; 46. *E. occidentalis*, Endlicher; 47. *E. paniculata*, Smith; 48. *E. patentinervis*, R. T. Baker; [*E. pauciflora*, Sieb., see 12. *E. coriacea*, A. Cunn.]; 49. *E. pilularis*, Smith; 50. *E. piperita*, Smith; 51. *E. Planchoniana*, F. v. M.; [*E. Platypus*, Hook., see 44. *E. obcordata*, Turcz.]; 52. *E. ptychocarpa*, F. v. M.; 53. *E. pulverulenta*, Sims.; 54. *E. punctata*, DC.; 55. *E. redunca*, Schauer; 56. *E. regnans*, F. v. M.; 57. *E. resinifera*, Smith; 58. *E. robusta*, Smith; 59. *E. rostrata*, Schlecht; 60. *E. rubida*, Deane and Maiden; 61. *E. rudis*, Endl.; 62. *E. saligna*, Smith; 63. *E. siderophloia*, Benth.; 64. *E. Sideroxylon*, A. Cunn.; 65. *E. Sieberiana*, F. v. M.; 66. *E. Smithii*, R. T. Baker; 67. *E. stellulata*, Sieb.; [*E. stricta*, Sieb., see 74. *E. virgata*, Sieb.]; 68. *E. Stuartiana*, F. v. M.; 69. *E. tereticornis*, Smith; 70. *E. trachyphloia*, F. v. M.; 71. *E. umbra*, R. T. Baker; 72. *E. urnigera*, Hook. f.; 73. *E. viminalis*, Labill.; 74. *E. virgata*, Sieb.

1. **Eucalyptus acmenoides,** Schauer. White mahogany.

A fairly tall straight-growing tree with drooping rather bushy foliage. Bark persistent, fibrous. Wood strong, tough and durable, used for posts, piles, building, &c.; posts are said to have lasted over fifty years in Australia. Indigenous in eastern New South Wales and Queensland, growing well on well-drained sterile hills. There are a few specimens in the Nilgiris. Mr. R. Bourne gives the following: (1) Coonoor Peak; (2) below Cluny Hall; (3) St. Thomas's churchyard. It is being experimented with further as a plantation tree and has done well so far. It has not attained a large size in the Nilgiris. It is being tried on the plains of northern India, but appears unlikely to thrive.

2. **Eucalyptus alpina,** Lindl.

A shrubby rare alpine species found on Mount William, Victoria, at an elevation of over 4,000 ft. Very slow-growing and of dwarf habit. Has recently been tried on the plains of northern India, but is most unlikely to succeed. A curiosity and not a species of commercial importance.

3. **Eucalyptus amygdalina,** Labill., including *E. regnans*, F. v. M. Giant gum, peppermint gum.

Maiden separates the two species, but they are here considered together because it is not yet certain to which belong the trees grown under the name of *E. amygdalina* in India. In its native home *E. regnans* is the largest of the eucalypts, trees over 400 ft. high having been recorded (F. v. Mueller). The stem is tall, straight and clean, with smooth almost white bark, and the foliage feathery and handsome. New South Wales, Victoria (eastern humid districts), and Tasmania, up to 4,000 ft. It attains its largest dimensions in well-watered ravines of the cooler ranges; in open country and on ridges it is a much smaller tree. Wood fairly light, floating in water, unlike that of most eucalypts, not very durable underground, but used for shingles, planking, and palings.

The leaves are very rich in oil, but perhaps this refers to the variety known as the peppermint gum, with fragrant leaves. The tree is grown to a certain extent in the Nilgiris: Mr. R. Bourne mentions the following: (1) Coonoor Peak, block I, compartments 4 and 7; (2) several fine specimens in Sim's Park, said to be about 30 years old (in 1912), the largest 114 ft. high and 11 ft. $1\frac{1}{2}$ in. in girth; (3) a few specimens near Wrenn and Bennett's; (4) Springfield, compartment 11, six fine specimens along the road. It has been under trial in the Simla hills since 1909, and so far it has been found to do moderately well at 4,000–6,000 ft. It has been tried on the plains of northern India, but according to Mr. R. N. Parker it has been found quite unsuitable. Dr. Brandis in 1876 reported a number of trees, believed to be this species, in the Changa Manga plantation, the largest, then eight years old, being 56 ft. high and 27 in. in girth; probably, however, the species was not correctly determined. It has done well at Maymyo in Burma (3,500 ft.).

Var. *coccifera*, Hook. f., has been tried without success on the plains of northern India. It is said to be very frost-hardy, and to have passed through severe winters in England.

4. **Eucalyptus Andrewsi,** Maiden. Blackbutt or peppermint (of New England), white top.

A tall tree with rough somewhat fibrous bark on the stem, and red twigs. Timber not of the first class, with many gum veins. Common in New England, New South Wales, generally on metamorphic rocks, on rocky ground with poor soil. Stands a considerable degree of cold. Has been tried recently on the plains of northern India, but is unlikely to prove successful.

5. **Eucalyptus Baileyana,** F. v. M. Rough stringybark.

A tall tree with dense shady foliage, attaining 150 ft. in Australia. Bark very rough and fibrous. Wood very tough, suitable for tool handles. South-east Queensland, on poor somewhat sandy ridges near Brisbane. Has recently been tried on the plains of northern India, but so far does not show much promise.

6. **Eucalyptus bicolor,** A. Cunn. Black box.

Usually a small tree or only a shrub. Has recently been grown at Dehra Dun and has established itself well so far.

7. **Eucalyptus botryoides,** Smith. Bastard mahogany.

A tall straight-stemmed tree with handsome dark green dense shady foliage resembling that of a *Eugenia*. Bark furrowed, outside greyish brown, inside rusty brown. Wood hard, tough and durable, used for large beams and felloes of wheels. South Queensland, New South Wales, Victoria, Tasmania, in moist localities along river flats and in mountain ravines. Also on coast sands, where it is somewhat gnarled; it is one of the few eucalypts suitable for such localities. Will endure excessive soil-moisture, but the growth suffers if the ground is too swampy. Unsuitable for dry climates. It is among the species grown in the Nilgiris. Mr. R. Bourne gives the following localities: (1) Cairn Hill, block III; a felled tree measured 97 ft. in height; (2) Sim's Park, compartments 2 and 3, and in the Park itself. It grows well at Coonoor. It has recently been tried at Dehra Dun, and has established itself satisfactorily so far. It has been tried in mangrove swamps in the Andamans, but without success.

8. **Eucalyptus calophylla,** R. Br. Orange-flowered gum.

A moderate-sized to large tree with broad almost equilateral *Eugenia*-like leaves, and easily recognized from its very large urn-shaped fruits. Seedling leaves peltate at the base. Bark persistent, dark brown, deeply furrowed, reddish and rather stringy on young trees. Wood not durable in the ground, but useful for spokes and tool handles, for which purpose it is replacing hickory. South-west Australia, often in jarrah (*E. marginata*) forests. An extra-tropical tree, but has succeeded fairly well in some almost equatorial regions, as at Zanzibar. Requires a mild equable climate, and does not stand frost. It is grown in the Nilgiris. Mr. R. Bourne gives the following localities : (1) Coonoor Peak, block I, compartments 10, 33, and 36 ; (2) Rallia ; (3) an aged specimen on the Coonoor *ghat* below Aravankadu on the north side of the road ; (4) Botanical gardens, Ootacamund, No. 17, 4 ft. in girth and 66 ft. in height. It was introduced experimentally in 1909 in the outer Himalaya below Simla, and so far has done well below 4,000 ft. It has recently been tried on the plains of northern India, but has not shown much promise.

9. **Eucalyptus Cambagei,** Deane and Maiden. Bastard box.

A low stunted tree with somewhat fibrous bark. Timber of no use. Victoria and New South Wales. It has been tried in the Simla hills since 1909, and has done well at 4,000–6,000 ft. and moderately well at 6,000–7,000 ft. elevation.

10. **Eucalyptus capitellata,** Smith. Brown stringybark.

A moderate-sized to tall straight or sometimes stunted tree with rather dense dark foliage and deeply fissured stringy bark. Wood tough, strong, durable, and fissile, used for construction, posts, shingles, and fuel. New South Wales (south-west and north of Sydney on poor rocky country), Victoria (Gippsland over 500 ft. and in places along the coast), South Australia (Mount Lofty). It is stunted and forms dwarf forests on moist sandy ridges. Suitable for wet sandy soil, and is found sometimes on moist flats. Grown in the Nilgiris, Cairn Hill, block III ; a tree 66 ft. in height was measured by Mr. R. Bourne. Has been tried on the plains of northern India, but has proved quite unsuccessful.

11. **Eucalyptus cinerea,** F. v. M. Argyle apple.

A handsome tree 40–50 ft. high, covered with a whitish bloom. Bark fibrous, thick. New South Wales. Has recently been tried on the plains of northern India, but does not show much promise.

Eucalyptus citriodora, Hook., see 36. *E. maculata*, Hook.

Eucalyptus coccifera, Hook. f., see 3. *E. amygdalina*, Labill.

12. **Eucalyptus coriacea,** A. Cunn. Syn. *E. pauciflora*, Sieber.

A moderate-sized tree, often with spreading branches, the branchlets more or less pendulous and often covered with a bluish bloom. Bark smooth, whitish grey. Wood rather soft and brittle ; an excellent fuel. Victoria, New South Wales, Tasmania, from the lowest elevations up to near the snow-line in the Australian Alps. Is capable of standing rather severe frost, and grows close to glaciers, forming dwarf forests with *E. Gunnii* up to 5,500 ft. Has been tried in the Simla hills since 1909, and has done moderately well at 4,000–6,000 ft. Recently tried on the plains of northern India, but failed.

13. **Eucalyptus cornuta,** Labill. Yate.

A tree reaching fair dimensions in its home, but usually of small or moderate size, with slightly drooping foliage. Bark dark greyish brown, rough. Wood hard and elastic, used for shafts, boat ribs, and agricultural implements. South-west Australia. It thrives best in moist localities and does well in a humid climate, but can grow on poor soil. It can stand a considerable degree of frost, trees in Florida having withstood temperatures as low as 23° F. Under favourable conditions its growth is rapid. It has been grown in the Nilgiris (Botanical gardens, Ootacamund). It was tried without success about 1874–6 at Saugor in the Central Provinces. It has been tried in the Simla hills since 1909, and so far has done moderately well below 4,000 ft. It was reported in 1911–12 to be growing well in a rubber plantation at Kwanhla in the Amherst township, Burma.

14. **Eucalyptus corymbosa,** Smith. Bloodwood.

A tall tree, but often small and stunted. Bark persistent, rough, blackish grey, yellowish or reddish brown inside, that of upper branches smooth and reddish or whitish. Wood very hard and durable, but difficult to saw owing to the quantity of kino in it, and not a good fuel; used for piles and fence-posts. Queensland, North Australia, and New South Wales; the commonest eucalypt in Queensland (Bailey). There is a specimen, which has not grown to any size, in the Nilgiris in Sim's Park, Forest Lodge. It has been tried in the Simla hills since 1909, and has done moderately well above 6,000 ft. It has recently been tried without success on the plains of northern India.

15. **Eucalyptus corynocalyx,** F. v. M. Sugar gum.

A moderately tall tree with smooth bark and sweetish foliage which attracts cattle and sheep. Wood durable and very strong; said to be better than hickory. South Australia and Victoria. Growth not very rapid. Very drought-enduring, but grows best with a fair amount of moisture: intolerant of excessive soil moisture. It has been tried since 1909 in the Simla hills at various elevations, and so far has done moderately well from below 4,000 ft. to over 7,000 ft. It has recently been tried on the plains of northern India, but so far it does not show much promise.

16. **Eucalyptus crebra,** F. v. M. Narrow-leaved ironbark.

A moderate-sized or large tree with long narrow leaves, slender drooping branchlets, and small flowers and fruits. Bark rough, deeply furrowed, grey to almost black. Wood hard, tough, elastic and durable, used for posts, piles, bridges, and wagons. Queensland, New South Wales, and North Australia; often gregarious. Grown in the Nilgiris. Mr. R. Bourne gives the following: (1) Sim's Park; (2) below Cluny Hall, one tree measured 4 ft. 10 in. in girth and about 40 ft. in height; (3) Botanical gardens, Ootacamund, 7 ft. 6 in. in girth and 92 ft. in height. Now being experimented with further as a plantation tree in the Nilgiris, but the growth of the young trees is very slow, and success is not anticipated. Has been tried in the Simla hills since 1909, and so far has done only moderately well from 4,000 ft. upwards. Occasionally seen on the plains of northern India (Lahore, Amritsar, Kapurthala, Changa Manga, Saharanpur, Lucknow). On the plains the success is variable and the growth is slow in youth. Parker says the growth is slow for eucalyptus, but he records a tree 7 ft. in girth and fully 100 ft. high in Amritsar, the age of

which could not have been more than fifty years, and may have been considerably less. Line sowings along with field crops made at Dehra Dun proved successful in the earlier stages, a thick crop over 6 ft. high having resulted after two years : the plants did not suffer from frost, though in the very early stages many died of drought. The lines were, however, left untended and the plants suffered from overcrowding. Flowers December–January, Punjab (Parker).

17. **Eucalyptus delegatensis,** R. T. Baker. White ash.

A tall tree with reddish stringy bark. Wood fissile, pale coloured, light, esteemed for indoor work. South-eastern part of New South Wales, Victoria, on mountain ridges. Has been tried on the plains of northern India, but does not show much promise.

18. **Eucalyptus dives,** Schauer. Broad-leaved peppermint gum.

A moderate-sized tree with very aromatic leaves. Bark rough on the stem, smooth and yellowish on the branches. Timber of little value. New South Wales and Victoria, on poor rocky ground, usually on granitic rock. Has been tried recently on the plains of northern India, but gives little promise of success.

19. **Eucalyptus eugenioides,** Sieber. White stringybark.

A tall tree with dense dark shining *Eugenia*-like foliage and almost horizontal side branches. Bark thick and very stringy. Wood durable, fairly hard, easily worked, splits easily into shingles, slabs, &c. ; used also for fence-posts, building, sleepers, paving-blocks, flooring, and other purposes. Bark used for roofing and inner bark for mats and packing. South Queensland, New South Wales, and Victoria, growing gregariously for the most part on elevated poor ground but descending into sandy low land. The tree grows very well in the Nilgiris, reaching a size not attained in its natural home. Mr. R. Bourne gives the following : (1) Coonoor Peak, block I, compartments 4 (girth 12 ft. 5 in.) and 36 ; (2) three or four fine specimens (one measured 113 ft. high and 10 ft. 7 in. in girth) in Botanical gardens ; (3) Sim's Park (girth 5 ft. 6 in. and 7 ft. 4 in., height $81\frac{1}{2}$ ft. and 95 ft. respectively) ; (4) below Walthamstow ; (5) one fine specimen on the roadside near the lake below Woodcot ; (6) Keti, Snowdon, Aramby experimental plantations. It has been tried in the Simla hills since 1909, and so far has done moderately well at 4,000–6,000 ft. elevation. It has recently been tried on the plains of northern India, but does not give much promise of success.

20. **Eucalyptus eximia,** Schauer. White bloodwood, mountain bloodwood.

A fairly tall tree with dark foliage. Bark persistent, somewhat scaly or flaky, yellowish, verging into a brown or grey tinge. Wood soft, not durable, containing kino ; a good fuel. Has been tried in the Simla hills since 1909, and has done well so far at elevations below 6,000 ft. Has recently been tried on the plains of northern India, but does not promise well.

21. **Eucalyptus ficifolia,** F. v. M. Scarlet-flowered gum.

A small bushy tree with broad stiff leaves, dark above, paler below, and clusters of large handsome crimson flowers. A very handsome tree, planted mainly for ornament. South-west Australia. Has been extensively planted for ornament in the Nilgiris. Has recently been tried on the plains of northern India, but does not promise well.

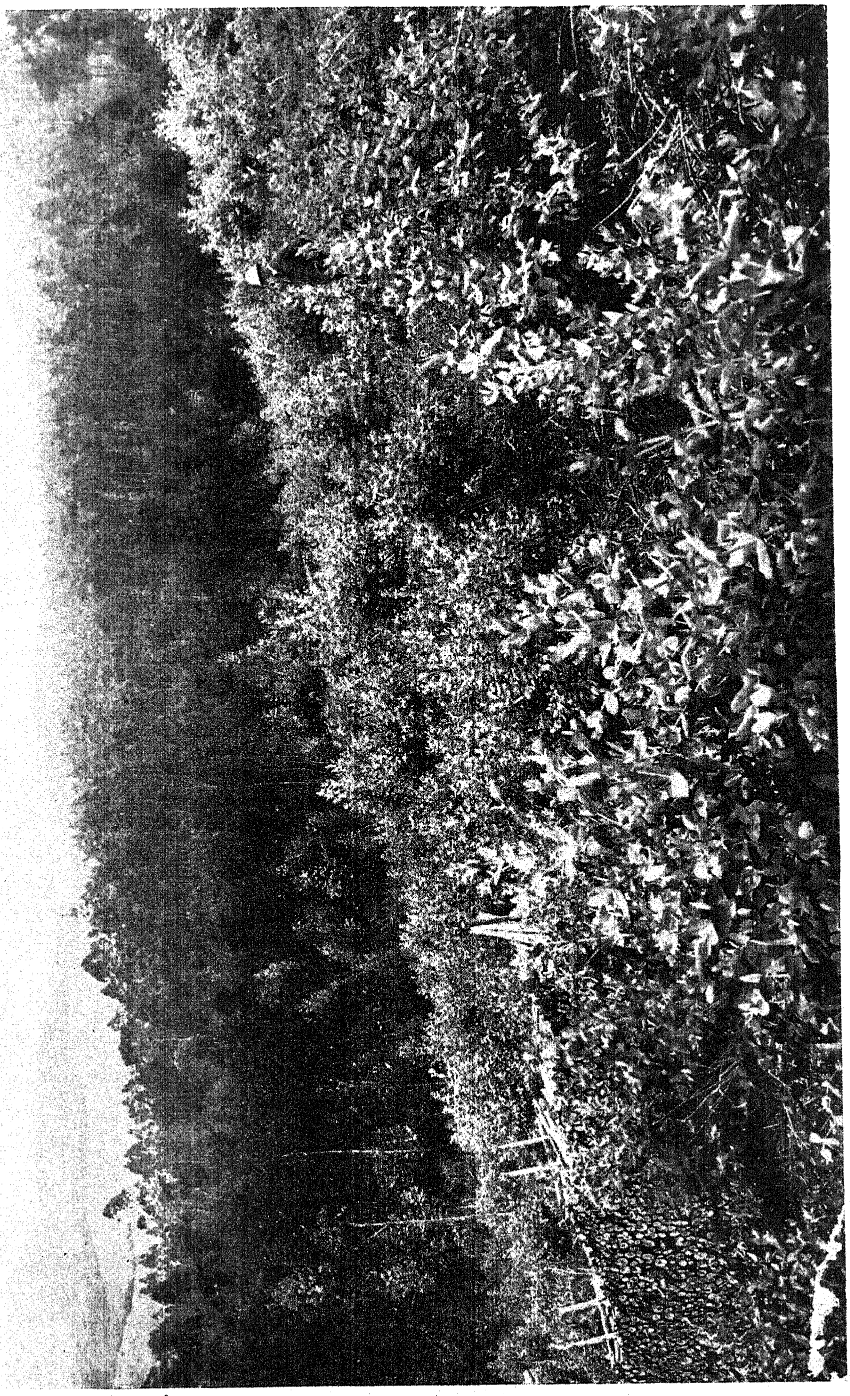

FIG. 216. *Eucalyptus Globulus* coppice, 7 months old, with older coupes behind, Nilgiris.

FIG. 217. *Eucalyptus Globulus* coppice, grassland type, 2 years old on left, 6 years old on right, the latter with mean girth 14·5 in., mean height 41 ft., volume per acre, 3,200 cubic ft. stacked, Aramby plantation, Ootacamund.

22. **Eucalyptus foecunda,** Schauer.

A shrub or small tree with dark green foliage and darkish smooth bark shedding in cartilaginous lamellae. Wood hard and elastic. Western Australia, chiefly on limestone, but also on sandy plains with a calcareous substratum. Grown in the Nilgiris, but rare; Sim's Park (R. Bourne).

23. **Eucalyptus Globulus,** Labill. Blue gum.

A very large tree, with a tall straight clean bole when grown under forest conditions, but often tending to branch freely when grown in the open. Bark constantly decorticating in brown strips of varying length, showing the young smooth greyish or bluish white bark; sometimes almost wholly persistent, and often rough at the base of the stem. The tree can be recognized by the quadrangular branchlets, the warty glandular calyx covered by a crown-shaped lid, and the characteristic leaves of seedlings and young coppice-shoots, which are opposite, sessile, cordate or cordate-ovate, covered with a bluish-white bloom and strongly impregnated with a gummy aromatic oil; the stems of seedlings and young coppice-shoots are sharply quadrangular. Primordial leaves are also produced by adult trees which have been injured by fire or otherwise, and a burnt plantation has a characteristic silvery appearance. In the Nilgiris ripe seed may be collected about May, but the seed does not fall naturally until about July–August. Samples of Nilgiri seed gave 6,500 to 9,400 per oz.; fresh seed gave the highest percentage of fertility, that kept for one year germinating fairly well, and that kept for two years germinating poorly. Fertile seed is produced at an early age: seed collected from coppice-shoots nine years old in the Nilgiris in 1912 showed a fertility of 47 per cent.

The wood is hard, heavy, and strong, and in its native home is considered durable, though not among the most durable of eucalypt timbers; it is much used for house-building (joists, rafters, &c.), ship-building, carriage-building, &c. In the Nilgiris it has an indifferent reputation as timber, owing to its tendency to warp and split, but has proved to be fairly durable and is used for fence-posts. Possibly its poor reputation is due to some extent to the employment of timber from immature trees, for in some cases timber of fair quality has been yielded by large-sized trees. So far as Indian experience goes, however, there is not at present sufficient justification for planting the blue gum on an extensive scale as a timber tree. In the Nilgiris it is the principal source of fuel supply, and owing to its rapid growth and high yield it is eminently suitable for cultivation as a fuel tree.

The blue gum is a native of Tasmania, Victoria, and New South Wales, where it occurs chiefly in the humid regions, in valleys as well as on ridges and mountain slopes; while common in most parts of Tasmania it is most plentiful in the south, but it does not ascend to alpine elevations. The blue gum has been more extensively planted than any other eucalypt in extra-tropical regions throughout the globe, its first introduction into southern Europe dating from the early part of last century. It was among the earliest of the eucalypts introduced into India, probably about 1843, when the first attempts were made to cultivate these trees in the Nilgiris.

The blue gum grows best in a moderately cool moist equable climate on deep fertile soil. It will endure excessive moisture, though not the equal of

E. rostrata in this respect: swampy ground, however, is not favourable to good growth. It is averse to calcareous and to saline soils. The seedlings are somewhat sensitive to frost and drought, and even in the Nilgiris, where the winter cold is by no means intense, they require to be protected from frost for the first year after planting out. The adult trees also do not stand severe frost or drought.

The blue gum has been tried from time to time in all kinds of localities throughout India, and from the experience gained it may be laid down that it is totally unsuitable for cultivation on the plains, or indeed at any elevation much below 4,000 ft. It has even been tried on coast sand in Madras, but needless to say the attempt was a complete failure. It has been planted in various parts of the Himalaya and has succeeded tolerably well in several places, particularly where the climate is not too severe, but it is very liable to breakage by snow, for which reason it is unsuitable for cultivation at altitudes where the snowfall is at all heavy. Prior to the abnormal frost of 1905 it was one of the commonest species grown at Abbottabad (4,000 ft.), but it was severely injured in the great frost, and many trees which had been killed outright were felled; there are now far fewer specimens there, and those which existed prior to 1905 are all injured. Experiments within recent years have shown that it grows well in the Simla hills at 4,000–7,000 ft. elevation. In Burma it has proved a failure at Maymyo (3,500 ft.) but has succeeded in the hills of the Ruby Mines district. It grows well at Shillong in Assam. It is in the Nilgiris, however, that this tree grows to the greatest perfection; it has been extensively planted at elevations varying from 5,000 to 8,300 ft., and is of paramount importance as a fuel-producing species. The climate of the Nilgiris has been described on pp. 558–9: being cool, equable, and moist it is an ideal one for the growth of the blue gum, while the red clayey soil overlying gneissic rock, and remarkably free from lime, appears to be specially favourable to the growth of the tree. The Nilgiri plateau is hilly to undulating, and consists largely of open grassy downs with *sholas*, or patches of dense evergreen forest of rather small-sized trees, occupying the more fertile hollows and ravines. Blue gum plantations have been formed both on grass-land and on *shola*-land, and the latter being more fertile the growth on this type of land is superior to that on the grass-land.

The blue gum plantations of the Nilgiris are worked mainly as simple coppice, the rotation adopted for some time past being ten years, but under the latest revised working plan[1] it has been raised to fifteen years, this rotation being likely to furnish a higher yield. Some of the plantations in the less accessible situations have remained as high forest, and these give some idea of the large dimensions attained by this tree. Coppice-with-standards was tried at one time, but the standards were found to interfere with the development of the coppice, and the system was therefore abandoned: some of the coppice-with-standards coupes have been allowed to grow up into high forest. The coppicing power of the tree is remarkable, numerous shoots being sent up both from the cambium round the top of the stool and from the periphery of the stool lower down, but chiefly from the latter; a callus forms over the top of the stool and may cover it completely in a few years.

[1] Working Plan for the Nilgiri Plantations, S. Cox, 1913.

Fig. 218. *Eucalyptus Globulus* coppice, 8 years old, grassland type, showing comparative absence of undergrowth, mean girth 13·2 in., mean height 48 ft., volume per acre 4,000 cubic ft. stacked, Aramby plantation, Ootacamund.

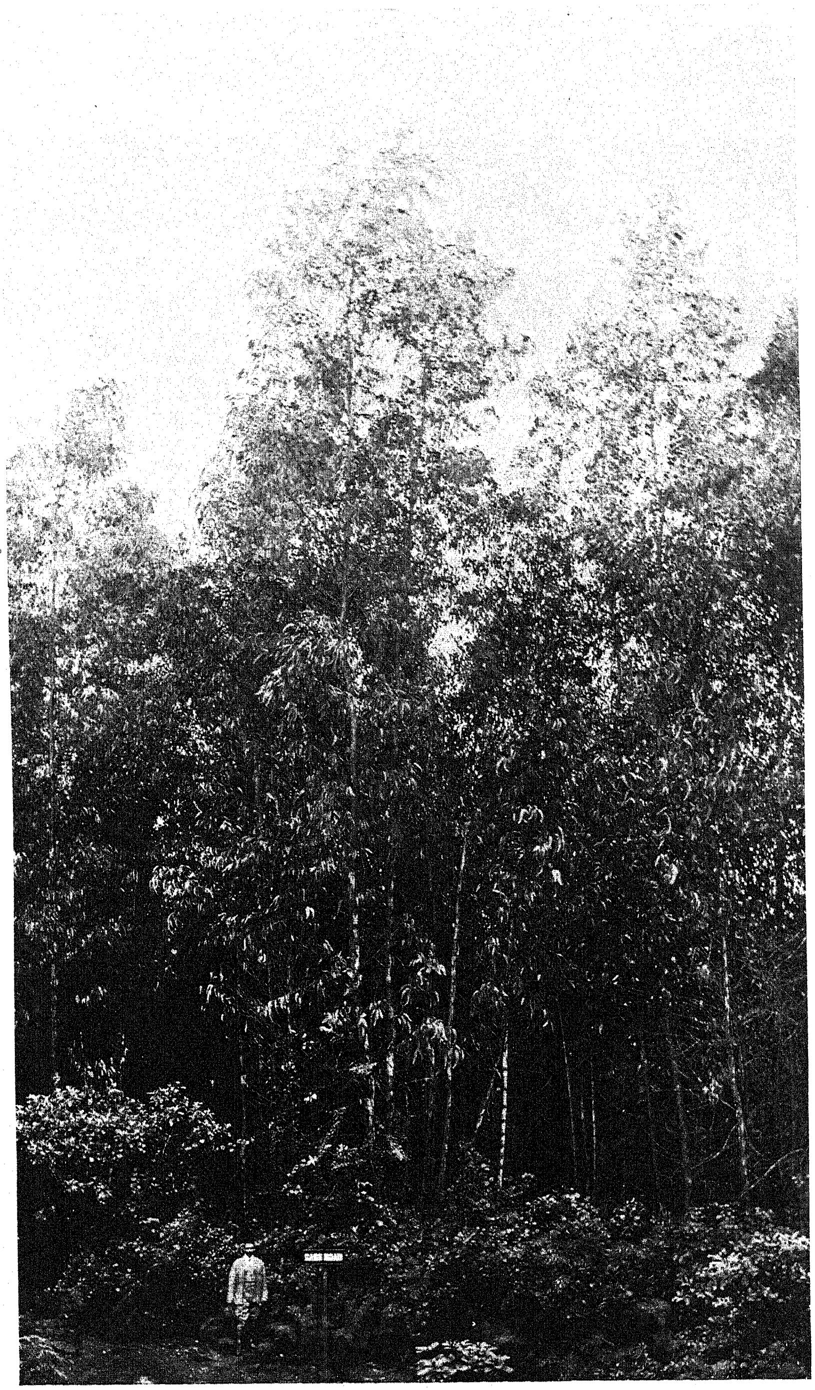

FIG. 219. *Eucalyptus Globulus* coppice on *shola* land, age 4 years, height 45 ft., Coonoor Peak plantation, Nilgiris.

The vitality of the stools is considerable, for there are several coupes in the Nilgiris already in their fourth rotation, the last two rotations being ten years and the first generally longer, and the stools are apparently as vigorous as ever. The young coppice-shoots grow rapidly, reaching a height of 3 or 4 ft. or more in a few months. Fig. 216 shows a young coppice coupe, with the characteristic opposite pale bluish green primordial leaves, and Figs. 217 and 218 show older coppice coupes of the grass-land type, where there is little undergrowth except grass. The extremely rapid growth of coppice on *shola*-land is shown in Fig. 219, which represents coppice four years old and 45 ft. high. The young coppice-shoots thin themselves out rapidly, the average number per stool at five years of age being about 3, while even up to twenty-five years of age it varies ordinarily from 2 to 3.

The dimensions attained by individual trees in the Nilgiris may be exemplified by the following measurements made by me in 1912, it being understood that where the age is unknown none of the trees can be more than sixty-nine years old: (1) Woodside, isolated tree, age unknown, girth 19 ft. 2 in., height 138 ft.; (2) Tudor Hall, more or less isolated, age unknown, girth 12 ft. 7 in., height 150 ft.; (3) Brooklands plantation, age fifty years, trees in open crop, rather branchy, without much height-growth, maximum girth measured 15 ft. 1 in. In 1905 Mr. Cowley-Brown measured a tree on the Woodcot estate fifty-one years of age with a height of 166 ft. and a girth of 18 ft. 10 in.

Excellent growth is also shown in the high forest plantations of the Nilgiris, but as most of these have not been regularly thinned and have become congested, the girth increment and volume production are not what they would otherwise have been. Figs. 220 and 221 show two typical high forest plantations of very good quality, the former (Aramby) thinned and the latter (Mutinad) in need of thinning. In the former particularly the dimensions attained are remarkable; the age in 1912 was forty-nine years, the average and maximum girths were 6 ft. 9 in. and 11 ft. 6 in. respectively, and the average and maximum heights were 175 and 185 ft. respectively. The Aramby plantation consists of standards in former coppice-with-standards, and the trees have had free growing space throughout the greater part of their life.

A series of measurements in coppice and high forest crops was carried out in the same year in the blue gum plantations of the Nilgiris, and the results are summarized below.[1] The coppice figures may be regarded as giving a very fair general average, since they are based on numerous measurements in crops of various ages: the high forest figures, however, are given for individual crops only, since the number of crops of different ages was insufficient to give general averages, while the absence of regular thinnings in the past prevents a true idea of the development of most of the crops being arrived at:

[1] See my note on the Blue Gum Plantations of the Nilgiris, Ind. For. Records, vol. v, pt. ii, 1913.

1. *Eucalyptus Globulus*: girth and height measurements, Nilgiri plantations.

	Mean girth.			Mean height.			
Age. years.	Grass-land. in.	*Shola*-land. in.	General average, *shola*- and grass-land. in.	Grass-land. ft.	*Shola*-land. ft.	General average, *shola*- and grass-land. ft.	Remarks.
				Coppice: general averages for stems of all sizes.			
5	9·0	..	9·8	30	..	33	
10	13·8	..	17·2	56	..	61	
15	..	..	21·4	..	..	74	
20	..	..	23·8	..	..	81	
25	..	..	25·2	..	..	85	
			High forest: individual measurements of plantations, not general averages				
30	..	51·0	..	..	163	..	Mutinad, unthinned plot: dominant trees only.
30	..	47·0	..	..	143	..	Mutinad, thinned plot: average of trees left after thinning, including both dominant and dominated stems. Fig. 221 shows this crop before thinning.
35	42·0	..	..	115	..	..	Little Rallia: quality poor.
37	..	65·7	..	..	172	..	Yeppakuchy.
40	..	56·0	..	..	156	..	Rallia.
40	..	89·0	..	..	162	..	Coonoor Peak, compt. 9: standards in former coppice-with-standards.
42	..	58·0	..	..	158	..	Newman.
49	..	81·0	..	..	175	..	Aramby, II, 5: standards in former coppice-with-standards, see Fig. 220.

2. *Eucalyptus Globulus*: number of stems and volume production and increment per acre, Nilgiri plantations.

	No. of stems per acre.		Volume per acre.				Mean annual increment per acre, solid volume.			
			Grass-land.	*Shola*-land.	General average, grass- & *shola*-land.		Grass-land.	*Shola*-land.	General average, grass- and *shola*-land.	
Age. years.	Dominant only.	Total of all classes.	Solid vol. cub. ft.	Solid vol. cub. ft.	Solid vol. cub. ft.	Stacked vol. cub. ft.	cub. ft.	cub. ft.	cub. ft.	Remarks.
			Coppice: general averages.							
5	..	2,080	1,270	..	1,700	2,576	271	..	340	
10	..	880	3,230	..	4,850	7,348	360	..	485	
15	..	590	..	..	8,050	12,197	..	..	537	
20	..	470	..	..	11,200	16,970	..	..	560	
25	..	..	..	..	14,400	21,818	..	..	576	
			High forest: individual crops, not general averages.							
30	94	526	..	14,212	..	..	..	474	..	Mutinad, unthinned plot.
30	174[1]	628	..	15,822	..	..	..	527	..	Mutinad, thinned plot, before thinning: see Fig. 221.
35	..	720	..	10,212	..	..	..	291	..	Little Rallia: quality poor.
37	..	228	..	11,843	..	..	..	320	..	Yeppakuchy.
			..	13,750	..	..	..	344	..	Eucalyptus } Rallia.
			..	3,992	..	..	..	100	..	*Acacia Melanoxylon* } Rallia.
40	302[2]	580[3]	..	2,090	..	..	..	52	..	*Shola* trees. } Rallia.
			Total	19,832	..	..	..	496		
			..	14,010	..	..	..	350	..	Standards — Coonoor Peak, compt. 9: former coppice-with-standards.
40	40	190	..	2,470	..	..	..	112	..	Coppice — Coonoor Peak, compt. 9: former coppice-with-standards.
			Total	16,480	..	..	..	462	..	
42	..	544	..	14,195	..	..	..	338	..	Newman.
49	51	..	..	12,704[4]	..	..	..	259	..	Aramby, II, 5: standards in former coppice-with-standards: see Fig. 220.

[1] Trees left after thinning: these include some dominated stems.
[2] Eucalyptus only.
[3] Includes acacia and *shola* trees.
[4] 15,606 cub. ft. stacked.

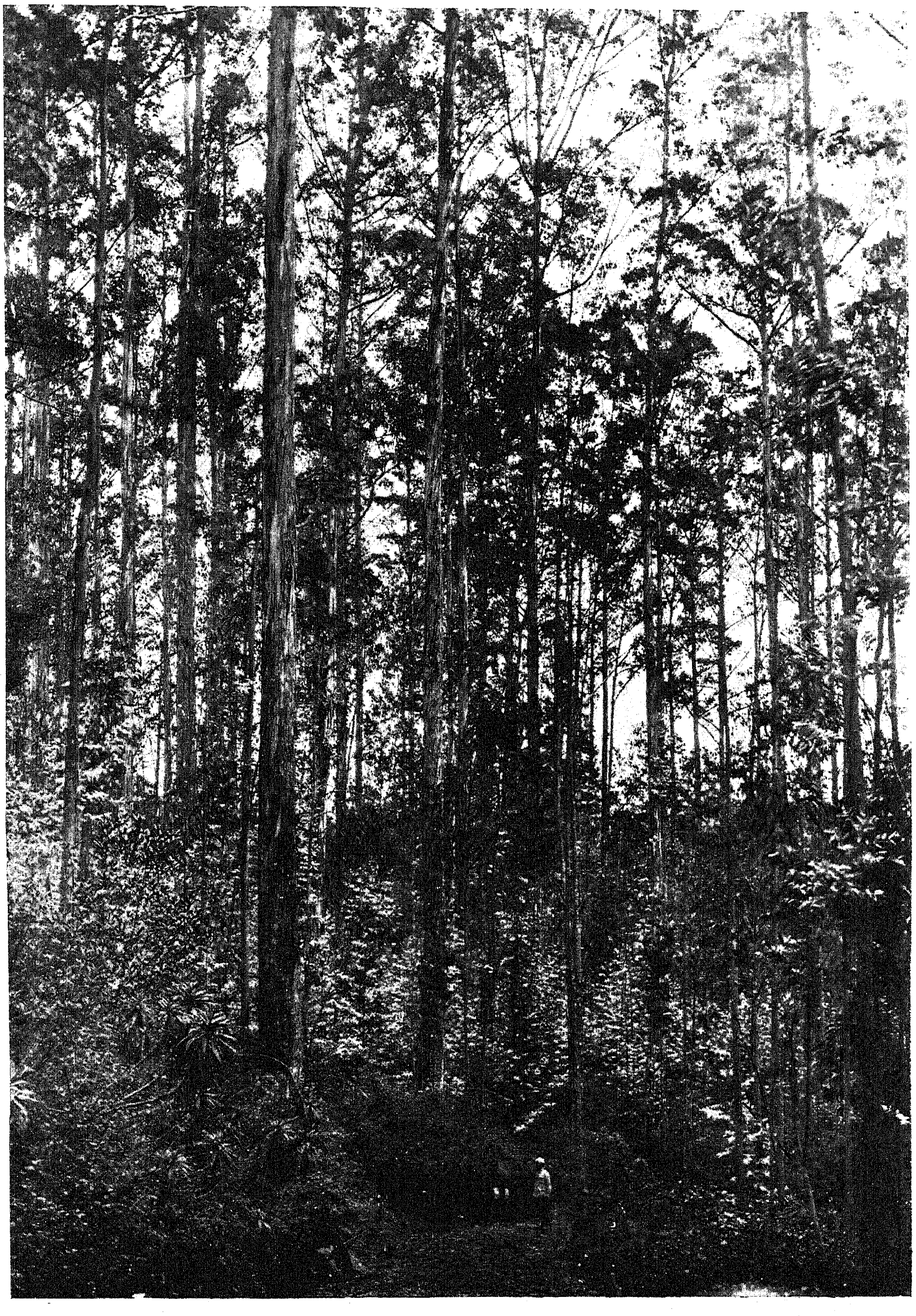

FIG. 220. *Eucalyptus Globulus* plantation on *shola* land; age 49 years; girth average 6 ft. 9 in., maximum 11 ft. 6 in., height average 175 ft., maximum 185 ft.; trees per acre 51, solid volume per acre 12,704 cubic ft., Aramby II. 5, Ootacamund.

FIG. 221. *Eucalyptus Globulus* high forest plantation, before thinning ; age 30 years ; after thinning, mean girth 3 ft. 11 in., mean height 143 ft. ; before thinning, stems per acre 628, solid volume per acre 15,822 cub. ft., Mutinad plantation, Nilgiris.

The following tables showing form factors and bark allowances have been compiled from the measurements made in 1912:

3. *Eucalyptus Globulus*: form factors, Nilgiri plantations.

Height. ft.	Form factor.	Remarks.
30–50	0·55	Average of 179 felled trees. Form factor, f, obtained from the formula $f = \frac{v}{sh}$, where v = volume of tree including bark, s = sectional area at breast height, and h = total height of tree: s and v obtained from true sectional area, πr^2.
51–70	0·54	
71–100	0·53	
over 100	0·51	

4. *Eucalyptus Globulus*: allowance for bark thickness, Nilgiri plantations.

Total girth of tree including bark.	Average thickness of bark. in.	Average allowance for bark in girth measurements. in.
Under 6 in.	0·1	0·6
6 in.–11 in.	0·25	1·6
1 ft.–1 ft. 11 in.	0·4	2·5
2 ft.–2 ft. 11 in.	0·6	3·8
3 ft.–3 ft. 11 in.	0·8	5·0
4 ft.–4 ft. 11 in.	0·9	5·7
5 ft.–5 ft. 11 in.	1·2	7·5
6 ft.–6 ft. 11 in.	1·3	8·0
7 ft.–7 ft. 11 in.	1·35	8·5
8 ft. and over	1·4	9·0

24. **Eucalyptus gomphocephala,** DC. Tooart.

A tall fairly shady tree. Bark persistent, rough and dark on old stems, greyish and smooth on younger stems and branches. Wood hard, strong, heavy, durable, difficult to split, used for ship-building, piles, bridge-construction, and other purposes. Western Australia, near the coast on limestone formation. Has been tried since 1909 in the Simla hills, and so far has done moderately well below 6,000 ft. Has recently been tried at Lahore and has succeeded fairly well hitherto, reaching a height of 16 ft. in four years.

25. **Eucalyptus goniocalyx,** F. v. M. Mountain gum, spotted gum of Victoria.

A very tall tree, in rich valleys attaining 300 ft. in height, but often much smaller and tending to branch low. Bark persistent, wrinkled or fissured, but somewhat variable. Wood hard, tough, and durable, difficult to split, used for boat-building, construction, wheel-work, posts, &c. Victoria and New South Wales; a rough-barked variety grows on low dry and stony ranges, and a taller variety with smoother bark is found in hilly country up to 3,000 ft., descending into wet valleys. Not usually gregarious. Has been tried since 1909 in the Simla hills, and has succeeded moderately well at elevations below 4,000 ft. Has been tried on the plains of northern India, but without success. It has recently been tried at Mercara in Coorg, and shows some promise.

26. **Eucalyptus Gunnii,** Hook. Swamp gum, cider gum.

A tree reaching large dimensions, but often crooked, and sometimes stunted. The leaves have not the strong aromatic odour characteristic of most eucalypts, and are therefore readily browsed by cattle and sheep. Bark constantly exfoliating in long strips, exposing the younger whitish bark. Wood

hard and of good quality, but straight stems are not always available ; usually splits with difficulty. South Australia, Victoria, New South Wales, and Tasmania, on alluvial flats, particularly in swampy places, but also on moist hill-sides and mountains, ascending in a dwarf state to 5,500 ft. A hardy species, standing a considerable degree of frost. It is cultivated in the Nilgiris ; Mr. R. Bourne gives the following : (1) Sim's Park, Forest Lodge ; (2) Botanical gardens, Ootacamund, No. 16, girth 4 ft. 2 in., height 63 ft. 6 in. ; (3) Cairn Hill, block III. It has been tried in the Simla hills since 1909, and has done well at elevations of 4,000–7,000 ft. and moderately well under 4,000 ft. It has been tried on the plains of northern India, but without success.

27. **Eucalyptus haemastoma,** Smith. White or scribbly gum.

A fairly tall slender erect tree with rather broad peppermint-scented leaves. Bark very white. Wood not of great value, not durable : a fair fuel. South Queensland, New South Wales, Victoria, and Tasmania, often on poor ground. Has been tried without success in the Simla hills and on the plains of northern India.

28. **Eucalyptus hemiphloia,** F. v. M. White or grey box.

A moderately tall tree with drooping foliage. Bark peeling off in long strips. Wood strong, hard, tough, close grained, and durable, used for posts, building, wheel-work, tool-handles, &c. South Queensland, sometimes extending into the tropics, New South Wales, Victoria, and South Australia, sometimes on flats but usually on rough dry hills or ridges. Not particular as to soil or climate. It is grown in the Nilgiris, where it is only a small tree. Mr. R. Bourne gives the following : (1) Sim's Park ; (2) below Cluny Hall, one tree measured 3 ft. in girth and about 35 ft. in height ; (3) St. Thomas's churchyard. It has been tried since 1909 in the Simla hills, and so far has done moderately well at elevations below 7,000 ft. It has recently been tried at Lahore, and has shown promise during the first few years, having reached a height of 22 ft. in four years.

29. **Eucalyptus Kirtoniana,** F. v. M.

A large tree with rough somewhat fibrous bark. According to Maiden this is a variety of *E. resinifera*, Smith, but whereas the latter cannot be grown on the plains, *E. Kirtoniana* has been grown successfully at Lahore and Saharanpur. According to Parker it does well on the plains provided it gets a good deal of moisture. There are a number of specimens in the grounds of the Punjab Club at Lahore. Flowers October–November (Parker).

30. **Eucalyptus Leucoxylon,** F. v. M. Victorian ironbark, white gum of South Australia.

A tree sometimes reaching a large size but usually crooked and of small size, with pendulous branchlets. Bark persistent, deeply fissured, very hard, and dark coloured ; a variety has the stem pale and smooth through the outer bark falling. The bark is rich in kino. Wood very hard, durable, and strong, used for wheel-work, shafts, railway sleepers, paving-blocks, axe-handles, &c. South Australia, New South Wales, and southern Queensland. The ironbark variety with persistent furrowed bark occurs chiefly on stony ridges or mountains of sandstone and slate formation. The white-barked variety occurs on alluvial plains around Adelaide. It has a wide range of climate and will grow even on poor soil. According to von Mueller it is one

of the best eucalypts for a moist tropical climate. There are specimens in the Nilgiris, but they have attained only small size. Mr. R. Bourne gives the following: (1) Government gardens, Ootacamund; (2) Sim's Park, compartment 1; and (3) along Walker's Hill road, where it forms a handsome avenue. It has been tried since 1909 in the Simla hills, and has done well so far at elevations below 4,000 ft.

31. **Eucalyptus longifolia,** Link and Otto. Woolly butt.

A large handsome tree with drooping foliage which turns a pink colour. Bark persistent, greyish brown, fibrous, very thick. Wood more useful for fuel than for timber; used for fence-posts. Victoria and New South Wales. It is grown in the Nilgiris, attaining a fair size. Mr. R. Bourne gives the following: (1) Sim's Park; (2) Botanical gardens, Ootacamund: two trees measured, (i) girth 10 ft. 2 in., height 95 ft. 6 in., (ii) girth 7 ft. 6 in., height 113 ft. 10 in. It has been tried in the Simla hills since 1909, and has done well so far at elevations below 6,000 ft. It has recently been tried on the plains of northern India, but does not show much promise.

32. **Eucalyptus macrandra,** F. v. M.

A shrub or small tree with smooth bark, a native of Western Australia. Has been tried recently on the plains of northern India, but has not shown much promise.

33. **Eucalyptus Macarthuri,** Deane and Maiden. Paddy's River box.

A moderate-sized tree with rough bark. A native of New South Wales, preferring low swampy situations. Has recently been tried on the plains of northern India, but has not shown much promise so far.

34. **Eucalyptus macrocarpa,** Hook.

A large shrub, mealy all over with a whitish bloom, leaves opposite, sessile, lobed at the base. Flowers large and handsome with orange or crimson stamens. Western Australia, in dry scrub forests. Has recently been tried on the plains of northern India, but does not promise well.

35. **Eucalyptus macrorrhyncha,** F. v. M. Victorian stringybark, red stringybark.

A tree sometimes attaining fair dimensions but usually of moderate size, with handsome drooping foliage. Bark persistent, greyish brown, thick, deeply fissured, stringy, used for roofing. Wood hard, durable, easily split, used for shingles, fencing, and boarding. South Australia, Victoria, and New South Wales, on comparatively sterile ridges and ranges, often gregarious, frequently mixed with *E. obliqua*, not usually ascending to any great elevation. It is grown in the Nilgiris. Mr. R. Bourne gives the following: (1) Sim's Park; (2) Botanical gardens, Ootacamund, No. 13, height 75 ft., girth 9 ft. 4 in. It has been tried in the Simla hills and also on the plains of northern India, but so far has proved unsuccessful.

36. **Eucalyptus maculata,** Hook. Spotted gum, including var. *citriodora*, Bailey (Syn. *E. citriodora*, Hook.), lemon-scented gum.

A tall straight clean-boled tree. Seedling leaves peltate at the base, rough with reddish hairs. Var. *citriodora* is distinguished from the normal variety by its strongly lemon-scented leaves. Bark smooth, whitish to reddish grey, falling off in patches, leaving an indentation where each patch was peltately attached and giving a spotted appearance to the stem. Wood strong, tough,

elastic, and durable, liable to warp in drying, easily split, used for wheel-work, carriage-building, tool-handles, ship-building, wood-paving, sleepers, &c. New South Wales and Queensland, the lemon-scented variety in Queensland. In its home it occurs usually on hilly ground. Outside its habitat it has been found incapable of resisting severe frost or excessive drought. It does best with considerable soil moisture, but will grow on fairly dry ground. In the severe frost of 1905 at Lahore young plants were killed but new shoots were sent up from the base; nursery plants at Dehra Dun are apt to be affected by frost in the winter unless protected. This is the species (var. *citriodora*) most commonly planted at Saharanpur and Dehra Dun, where it grows well and rapidly, though it runs to height rather than to girth. An avenue of this species was planted in the Forest Research Institute grounds at Dehra Dun in 1914. It also grows well at Lucknow and other stations of northern India. In the Punjab it is less common; seedlings are somewhat difficult to raise at Lahore. It is fairly common at Abbottabad. There are several specimens in the Nilgiris: Mr. R. Bourne gives the following: (1) Sim's Park, a specimen in the front of the Lodge; (2) in Mr. C. Mackenzie's garden at Ootacamund; (3) Botanical gardens, Ootacamund, girth 4 ft. 4 in., height about 70 ft.; (4) Sim's Park, compartment 1, in front of Forest Lodge; (5) a solitary specimen growing in the Moyar forest by the side of the Masnigudi–Tappacadu road, where it seems to be thriving fairly well. It was tried in 1913 at Mercara, Coorg, and so far has proved one of the best species experimented with, having attained a maximum height of 21 ft. and a maximum girth of 7 in. in three years. There are some trees at Maymyo in Burma, planted about 1893 and doing well. Flowers February–March, Punjab (Parker).

37. **Eucalyptus Maideni,** F. v. M.

A tall straight tree with smooth white or bluish bark. New South Wales, at 1,000–2,000 ft., often on steep slopes. It has been tried since 1909 in the Simla hills, and has done well at 4,000–7,000 ft., and moderately well under 4,000 ft. elevation.

38. **Eucalyptus marginata,** Smith. Jarrah.

A large tree, averaging 100 ft. and reaching 150 ft. in height, sometimes buttressed at the base. Bark persistent, greyish brown, somewhat fibrous. Wood extremely durable, though not by any means the strongest of eucalypt timbers. It lasts for a long time under various conditions, not only in or on the ground, but also under water, and is said to be immune from the attacks of teredo in the sea. One of the best known timber trees in the world: wood largely used for piles, construction of all kinds, railway sleepers, paving-blocks, ship-building, &c. Jarrah sleepers have been imported into India in quantity for several years past. It occupies an area estimated at 8,000,000 acres in the south-western part of Western Australia, growing gregariously and at its best on hilly country on granite and ironstone, while on the sandy plains near the coast it is scattered and inferior in quality. Its region has an average rainfall of 30 to 40 in., and is peculiar in having regular winter rains from April to October. Where tried outside its habitat it has been found to be readily affected by frost, and to be unsuited for dry soils, requiring a moist but well-drained soil. Its introduction into India has been attempted from time to time, but so far as is known it has not yet been successfully established.

It has been tried and found quite unsuitable for the plains of northern India. At Lucknow it was found incapable of standing the rains. Brandis reported in 1876 that it was cultivated in the Nilgiris, but no specimens are known to exist there now. Seed was sown in 1909 in the Sanyasimalai plantation, North Salem, Madras, at an altitude of 4,000 ft., and the seedlings are reported to have done well during the first year, but no further reports are available.

39. **Eucalyptus melanophloia,** F. v. M. Silver-leaved ironbark.

A tree with a spreading crown and opposite sessile silvery leaves. Bark dark, rough. Wood hard and close grained. New South Wales, Queensland, in open country. This species is grown in Lahore, Changa Manga, Agra, and Saharanpur. When young it is apt to grow spindly and requires staking. Given sufficient water the growth is fairly fast; at Lahore young plants reached a height of 24 ft. in four years. It stands drought well. Flowers May–June, Punjab (Parker).

40. **Eucalyptus melliodora,** A. Cunn. Honey-scented gum, yellow box.

A moderate-sized tree, occasionally attaining large dimensions, with pendulous branches and slender branchlets. Bark brownish grey outside, yellow inside, more or less persistent. Wood yellowish, very hard, heavy, tough, and durable, used for wheel-work, posts, &c., but not very suitable for sawing into planks; an excellent fuel. Victoria and New South Wales, chiefly on ridges but descending into valleys. Will live on poor soil. Has been tried since 1909 in the Simla hills, and has done moderately well at elevations below 6,000 ft. Recently tried at Lahore, and has shown promise during the first few years, having reached a height of 25 ft. in four years.

41. **Eucalyptus microcorys,** F. v. M. Tallow-wood, wangee.

A large tree with reddish fibrous persistent bark. Wood very tough and durable, used for house- and ship-building, sleepers, wheel-work, &c. New South Wales and southern Queensland, on arid or sandy hills, on the coast side of the ranges. Comparatively rare in the Nilgiris: Sim's Park, a good specimen above the drive to Sim's Park Lodge (R. Bourne). Has been tried since 1909 in the Simla hills, and so far has done moderately well below 4,000 ft. Has recently been tried with some success at Saharanpur.

42. **Eucalyptus miniata,** Cunn.

A very ornamental tree with red flowers. Bark with external appearance and fracture resembling mica-schist. North Australia and Queensland. Nilgiris, in Sim's Park reserve (R. Bourne).

43. **Eucalyptus Muelleriana,** Howett. Yellow stringybark.

A tree often attaining 60 ft. in height, with straight massive bole and moderately spreading branches. Bark dark grey, fibrous, fissured. Wood of good quality, fissile, very durable. South Australia, Victoria, and New South Wales, usually on broken country, preferring the taluses of hills on moderately good soil and avoiding exposed situations (Maiden). It has been tried experimentally in the Simla hills since 1909, but has proved unsuitable for introduction on a large scale. It has also been tried recently on the plains of northern India, but does not show promise.

44. **Eucalyptus obcordata,** Turcz. Syn. *E. Platypus*, Hook.

A large shrub or small tree with broad leaves with wavy margins and very broad flattened flower-stalks. Bark smooth, greyish. Western Australia,

often forming almost impenetrable thickets. Has recently been tried on the plains of northern India, but gives little promise of success.

45. **Eucalyptus obliqua,** L'Hérit. Stringybark (South Australia and Tasmania), messmate tree (Victoria).

A very tall straight tree, attaining a maximum height of about 300 ft. Bark persistent, very fibrous, greyish outside, brownish red inside, rather soft. Wood not very durable but much used, owing to its abundance, for rough building purposes; very fissile, and extensively split into palings, shingles, &c. It is said to be an indifferent fuel, but this has not been found to be the case in the Nilgiris, where it is much used. The bark is used for roofing. South Australia, Victoria, New South Wales, and Tasmania, one of the commonest and most gregarious of the eucalypts, forming vast forests and extending to high but not to alpine elevations. It does not stand drought. After *E. Globulus* this is one of the commonest species in the Nilgiris, where it reaches large dimensions. It was tried at Saugor in the Central Provinces in 1874–6, but failed. It has been tried in the Simla hills at various elevations, but so far has not proved successful. It has failed hitherto on the plains of northern India, but recently it has given more promise of success in the early stages at Saharanpur.

Eucalyptus obtusifolia, DC., see 74. *E. virgata*, Sieb.

46. **Eucalyptus occidentalis,** Endl. Flat-topped yat.

A moderate-sized tree, attaining fairly large dimensions in favourable localities, but often little more than a shrub. Wood hard and strong, used for wheel-work. Western Australia, on clayey as well as on sandy soil, and also in wet places. Has recently been tried on the plains of northern India, but does not show much promise.

47. **Eucalyptus paniculata,** Smith. White ironbark.

A moderate-sized tree, attaining a height of 60 to 70 ft. Bark persistent, hard, rough, brown. Wood strong and very durable, much used for wheel-work, carriage-building, construction, sleepers, posts, &c. Chiefly in New South Wales in the coastal regions; also in Victoria. It can stand poor dry soil but not excessive heat or drought. There are specimens in the Nilgiris: Sim's Park, Forest Lodge (R. Bourne). It has recently been tried experimentally for plantation work in those hills, but so far the growth has been slow. It has been tried since 1909 in the Simla hills, and has done well hitherto at elevations below 4,000 ft. It has been grown for some time at Saharanpur, and there are a few trees at Changa Manga. Flowers September–October, Punjab (Parker).

48. **Eucalyptus patentinervis,** R. T. Baker. Bastard mahogany.

A large tree with angular branchlets and bark resembling that of some species of pine. New South Wales. Has recently been tried at Dehra Dun and has established itself, but has not been tried long enough to give definite results.

Eucalyptus pauciflora, Sieb., see 12. *E. coriacea*, A. Cunn.

49. **Eucalyptus pilularis,** Smith. Blackbutt.

A very large tree. Bark persistent at the base, greyish, fibrous, and rough, falling off in strips from the upper part of the trunk and branches. Wood hard, tough, and durable, used for building, ship-building, paving-blocks,

posts, &c. Queensland, New South Wales, and Victoria. Usually a mountain tree, but sometimes found on level ground along rivers; prefers a damp climate and a moist rich soil. It is not common in the Nilgiris, and does not attain the large dimensions reached in its native home: Mr. R. Bourne records a tree in Sim's Park 116 ft. high and 5 ft. 6 in. in girth. It is being further experimented with in the Nilgiris as a plantation tree, and so far has shown promise. It was tried at Mercara, Coorg, in 1913, and has done well so far. It has proved a failure in the Simla hills and on the plains of northern India.

50. **Eucalyptus piperita,** Smith. Sydney peppermint.

A moderate-sized tree, closely akin to *E. pilularis,* but with rougher bark extending to the branches. Wood said to be of inferior quality. Victoria, New South Wales, and Queensland, on rather poor ground. Has been tried in the Simla hills and on the plains of northern India, but without success.

51. **Eucalyptus Planchoniana,** F. v. M.

A moderate-sized tree with angular branchlets and flattened petioles. Bark persistent, more or less fibrous. Wood hard and heavy, used for house-building. Local in southern Queensland and New South Wales on sandy or rocky ridges. Has been tried since 1909 in the Simla hills and has done moderately well between 4,000 and 6,000 ft. elevation. Has recently been tried on the plains of northern India, but does not promise well.

Eucalyptus Platypus, Hook., see 44. *E. obcordata,* Turcz.

52. **Eucalyptus ptychocarpa,** F. v. M.

A moderate-sized tree with persistent greyish, wrinkled, somewhat fibrous bark, ornamental red flowers, and longitudinally ridged fruits. North Australia, along rocky streams and dry watercourses. Nilgiris: (1) Cairn Hill; (2) plentiful along the Walker's Hill road in Coonoor; (3) two or three fine specimens along the Ghat road from Aravankadu to Wellington (R. Bourne).

53. **Eucalyptus pulverulenta,** Sims. Silver-leaved stringybark.

A small scraggy tree with bluish white glaucous opposite sessile leaves and grey stringy bark. Wood brittle and twisted. Victoria and New South Wales. It has been grown to a small extent in the Nilgiris: Mr. R. Bourne gives the following: (1) Botanical gardens, Ootacamund; (2) Cluny Hall compound; (3) in a small plantation above the Sigur Ghat road, just beyond the junction of the Lascelles and Sigur roads.

54. **Eucalyptus punctata,** DC. Leather jacket, hickory gum.

A moderate-sized to large tree of spreading habit, with dark rough bark. Wood hard, tough, extremely durable, difficult to split, used for sleepers, fence-posts, wheel-work, building, &c.; a good fuel. New South Wales, usually in dry rocky places. It is grown in the Nilgiris (Sim's Park), and is receiving a further trial there as a plantation tree, showing good promise so far. It was tried at Mercara, Coorg, in 1913, and has proved successful in the early stages. It has been tried in the Simla hills since 1909, and hitherto has succeeded moderately well at elevations below 4,000 ft. Recently it has been tried along the railway between Lakhsar and Hardwar, and so far has done well on dry stony ground.

55. **Eucalyptus redunca,** Schauer. Wandoo, white gum (Western Australia).

A large tree with persistent smooth white bark. Wood hard, heavy,

durable, and very tough, much in demand for building, wheel-work, shafts, and tool-handles. Western Australia, forming extensive forests and more plentiful in the south-western parts of Australia than any species except *E. marginata*. It grows on hill slopes and on flats, being content with poor soil and even badly-drained ground. It is grown in the Nilgiris (Sim's Park), but is apparently uncommon (R. Bourne).

56. **Eucalyptus regnans,** F. v. M. See under 3. *E. amygdalina,* Labill.

Trees raised from seed imported under the name *E. regnans* have been under trial since 1909 in the Simla hills, and so far have done moderately well from 4,000 to 6,000 ft. elevation. This species has also recently been tried on the plains of northern India, but does not promise well.

57. **Eucalyptus resinifera,** Smith. Red mahogany.

A large tree, forming a tall straight clean bole. Bark rough, fibrous, persistent, decorticating on the branches, deep reddish brown in the young trees, changing to light grey and brown on older stems. Wood a rich red colour, strong and durable, used for piles, fence-posts, and building. The tree exudes kino. New South Wales and southern Queensland, not extending far inland. It prefers a moist semi-tropical climate, growing best on deep fertile ground; it will grow on a variety of soils, including poor gravel and sand, and is drought-resistant, but will not stand badly-drained swampy ground. It has proved exceptionally frost-resistant in Florida, having withstood temperatures of 19° F. without damage.[1] It is grown in the Nilgiris (Sim's Park), but is apparently rare (R. Bourne). It has recently been under trial in the Sanyasimalai plantation, North Salem, at an elevation of 4,000 ft. Its cultivation has been attempted in the Simla hills since 1909, so far with moderate success at elevations below 4,000 ft. It has been tried on the plains of northern India, but without success: a species introduced about 1865 and successfully cultivated at Lucknow under the name of *E. resinifera* was in 1876 finally determined to be *E. saligna,* Smith. Mr. R. N. Parker notes that for many years *E. rostrata* and *E. tereticornis* have been distributed from the Agri-Horticultural Gardens, Lahore, under the name of *E. resinifera*. This species has done fairly well at Maymyo in Burma (elevation 3,500 ft.). It was tried in the Andamans in 1914, and showed some promise after the first year. It has been found to do well in the neighbourhood of Mercara in Coorg, at 4,000 ft., in places sheltered from the force of the south-west monsoon, and it is proposed to plant such areas with this species for the fuel supply of Mercara.

58. **Eucalyptus robusta,** Smith. Swamp mahogany.

A moderate-sized to large tree with stout angular branchlets, large leaves, and somewhat spreading habit, making it suitable as a shade tree. Bark persistent, wrinkled, and somewhat furrowed, grey outside, sometimes turning a rusty colour. Wood rather brittle, difficult to split, fairly durable, used chiefly for building. New South Wales and Queensland, growing best in regions not far from the sea. This tree prefers moist situations, but will grow under a variety of conditions; it is particularly well adapted for thriving in badly-drained swamps, though not quite so tolerant of swampy ground as *E. rostrata*. It is somewhat sensitive to frost. The growth is fast. There are

[1] Eucalypts in Florida, R. Zon and J. M. Briscoe, U.S. Dept. of Agriculture, For. Serv. Bull., No. 87, 1911, p. 21.

a few trees in the Nilgiris. Mr. Bourne records two in Sim's Park: (1) girth 9 ft. 9 in., height 60 ft.; (2) girth 7 ft., height 80 ft. He states that no trace of this species can be found in the plantations, and where references to it are made in old records *E. obliqua* was evidently meant. It is grown in various parts of the plains of northern India and in the sub-Himalayan tract, where it is worth growing only in moist situations, being unsuccessful in even moderately dry places; young plants grow vigorously, but older trees often become misshapen and ugly. It was recently tried in mangrove swamps in the Andamans, but was unable to stand the salt water; it showed some promise during the first year on ground farther inland.

59. **Eucalyptus rostrata,** Schlecht. Red gum.

A large tree attaining a large girth, sometimes erect and symmetrical, but often irregular in shape, with drooping foliage. Bark smooth, ashy grey or whitish, often mottled with brown. Wood strong and very durable, used for railway sleepers, piles, bridge-construction, ship-building, wheel-work, and many other purposes; a very good fuel. Victoria, South Australia, Western Australia, New South Wales, Queensland, and North Australia; not in Tasmania. This is one of the most important timber trees of Australia, not only because of its useful timber, but also because of its wide range and great abundance. It has been introduced into various parts of the globe, and grows under a variety of climatic conditions and in various situations and soils, preferring moist alluvial valleys and river-banks, but enduring considerable drought. It is particularly well adapted for growing in moist swampy localities, being probably unsurpassed by any other eucalypt for this purpose. It stands a considerable degree of frost as well as of heat; in California it endures minimum temperatures of 15° to 20° F., and maximum temperatures of 110° to 115° F.[1] The growth is rapid, though not equal to that of *E. Globulus*.

It is grown in the Nilgiris, where it coppices badly; Mr. R. Bourne gives the following localities: (1) Cairn Hill, block I, compartment 3 in the swamp, and block II, compartments 4 and 5; (2) Aramby, in a few places. It was tried without success at Saugor, Central Provinces, in 1874–6. It was sown in 1909 in the Sanyasimalai plantation, North Salem (elevation 4,000 ft.), and did well in the early stages. It has been tried since 1909 in the Simla hills, and has done well up to date at elevations below 4,000 ft. It is one of the species grown at Abbottabad (4,000 ft.). On the plains of northern India it thrives well and grows rapidly. In the Changa Manga plantation this species and *E. tereticornis* have proved more successful than any other eucalypt hitherto tried, and when once established they can hold their own against the mulberry. At Maymyo, Burma (elevation 3,500 ft.), it has done better than any other species tried so far; the fine avenue in the Maymyo bazaar consists chiefly of this species. It has recently been tried in the Andamans, and has shown promise in the early stages. It is cultivated at Calcutta, Poona, and other low elevations. Flowers May–June, Punjab (Parker).

60. **Eucalyptus rubida,** Deane and Maiden. Candle-bark.

A tree with smooth glaucous bark, often with reddish patches, the outer layer falling off in ribbons. New South Wales and Victoria. It has recently been tried on the plains of northern India, but has not shown much promise.

[1] Eucalyptus, its History, Growth, and Utilization, C. H. Sellers, California, 1910.

61. **Eucalyptus rudis,** Endl. Swamp gum, flooded gum.

A moderate-sized to large tree with leaves rich in oil. Bark greyish, usually rough and persistent, but sometimes flaking off and leaving the trunk smooth. Wood useful for fuel, and also used for posts. Western Australia, on river-banks and around swamps. In California it has proved remarkably hardy to heat and cold, enduring minimum temperatures of 15° to 18° F., and maximum temperatures of 110° to 118° F.[1] It has been tried since 1909 in the Simla hills, and so far has proved fairly successful at elevations below 6,000 ft. Within recent years it has been tried on the plains of northern India and in the sub-Himalayan tract (Lahore, Saharanpur, Lucknow, Dehra Dun), and has proved extraordinarily successful. A tree situated in the worst plot of land in the Government Agri-Horticultural Gardens, Lahore, attained a height of 50 ft. and a girth of 2 ft. 5 in. in four years.[2] This tree formed one of a row of trees growing vigorously in a patch of saline soil in which the salt-weed (*Suaeda fruticosa*) could hardly grow, and where all ordinary plants were incapable of living; at three years of age they averaged 30 ft. in height. Mr. R. N. Parker,[3] in describing these plants at Lahore, notes that for satisfactory growth, *E. rudis* apparently requires a very dry climate; the Lahore plants received constant irrigation since they were planted, but an abundance of water is not essential, as in the Kot Lakhpat plantation near Lahore this species is growing remarkably well with only moderate irrigation and with long intervals between successive watering. This species is doing well at Lucknow, and is reported to be thriving on swampy ground between Lakhsar and Hardwar.[4] Flowers October to February (Parker).

62. **Eucalyptus saligna,** Smith. Grey gum.

A tall straight tree with deciduous rather thick grey bark. Wood very hard, tough, and close grained, used for ship-building, carpentry, &c. New South Wales and southern Queensland, often plentiful on ridges, but also frequent along banks of streams. Said to prefer a deep moist soil and to be sensitive to drought. In Florida a tree has withstood temperatures of 22° F. without serious injury; another tree in an exposed situation was bent and dwarfed by the wind.[5] It is grown in the Nilgiris (Sim's Park). It has been tried in the Simla hills since 1909, and has done moderately well above 4,000 ft. It grows well on the plains of northern India, but apparently in most of the older reports the name *E. saligna* has been applied to totally different species. On the other hand, at Lucknow specimens of what were at first considered to be *E. resinifera* were in 1876 finally determined to be *E. saligna*; one tree was reported in 1877 to have attained a height of 45 ft. and a girth of 3 ft. 9 in. at 3 ft. from ground-level in ten to twelve years. Recently this species has again been tried at Lucknow, and so far it has proved very promising. It has recently been tried at Mercara in Coorg, and shows some promise. Mr. R. N. Parker[6] notes that on the Punjab plains he has seen this species only in Amritsar, where there are a number of specimens growing remarkably well; seedlings sown in Lahore in 1912 died off in large numbers during the monsoon, but the survivors were quite healthy and vigorous the following year. The

[1] Sellers, *loc. cit.*, p. 73.
[2] Garden Report, 1914–15.
[3] Ind. Forester, xl (1914), p. 452.
[4] Report Gov. Bot. Gardens, Saharanpur, 1915–16.
[5] Zon and Briscoe, *loc. cit.*, p. 26.
[6] Ind. Forester, xxxix (1913), p. 85.

plants reached a height of 12 ft. in three years. Flowers May, Punjab (Parker).

63. **Eucalyptus siderophloia,** Benth. Sydney ironbark. (The name broad-leaved or large-leaved ironbark is the one more correctly applicable to var. *rostrata*, the young leaves of which are often 2 to 6 in. wide).[1]

A large tree with a straight stem. Bark persistent, dark brown to nearly black, thick, deeply furrowed. Wood close grained, very hard, heavy and durable, largely used for building, bridge-construction, railway sleepers, wheel-work, and other purposes for which great strength is required; this is the principal ironbark tree in its native home. New South Wales and southern Queensland. A tree in Florida about ten years old measured 55 ft. in height and 13·7 in. in diameter; it was growing on dry soil and had withstood a temperature of 22° F.[2] In the Nilgiris there is a small plantation beyond Forest Lodge in Sim's Park, where this species is growing well (R. Bourne). It is now being experimented with further as a plantation tree in those hills, and has hitherto shown fairly rapid growth. There is a specimen doing well in the Changa Manga plantation near Lahore. It has been tried at Lucknow since 1912, and so far has done well. At Lahore seeds of this species were sown in 1911, and the plants reached a height of 11 ft. 7 in. in three years, but failed in the fourth year. Flowers April, Punjab (Parker).

64. **Eucalyptus Sideroxylon,** A. Cunn. Red ironbark, Victoria ironbark.

A moderate-sized or large tree with narrow silvery leaves and hard, rough, dark-coloured bark. Wood dark red, very hard, heavy, strong, and durable, used for railway sleepers, beams and girders, shafts and wheel-work. New South Wales, Victoria, and Queensland, usually on poor sterile ranges. In California it endures minimum temperatures of 16° to 20° F., and maximum temperatures of 110° to 112° F.[3] It was tried without success at Saugor, Central Provinces, about 1874–6. It is reported to have done well in the Kumaun hills, and is one of the species grown at Abbottabad, where it survived the severe frost of 1905. It has been tried since 1909 in the Simla hills, and has done moderately well between 4,000 and 6,000 ft. It has been tried at Changa Manga, but does badly; the heartwood of the trees becomes eaten by white ants. Not suitable for the plains. In India it tends to form a crooked bole and to produce large branches. Flowers September, Punjab (Parker).

65. **Eucalyptus Sieberiana,** F. v. M. Yohut, mountain ash.

A large tree attaining 120 ft. in height. Bark dark brown or grey, deeply furrowed, red and scaly on young trees, smooth and pale on branches. Wood tough and elastic, not durable when exposed to the weather, used chiefly for ship-building, tool-handles, and carriage-building; a good fuel. South Australia, Victoria, New South Wales, and Tasmania, frequent on poor barren ground or sandy soil on rocky and stony mountain ranges, ascending on southerly aspects to 5,000 ft. This tree has been grown to some extent in the Nilgiris, where it is found almost always as coppice; older trees are of rather crooked growth. Mr. R. Bourne gives the following localities: (1) Cairn Hill, block II, compartments 1, 4, 11, 12, 13, 14, and 19, and block III; (2) Aramby, block II, compartments 13 and 14; (3) Baikie, compartments 3 and 5. It has been

[1] Bailey, Queensland Woods.

[2] Zon and Briscoe, *loc. cit.*, p. 27.

[3] Sellers, *loc. cit.*, p. 73.

tried without success in the Simla hills and also on the plains of northern India.

66. **Eucalyptus Smithii,** R. T. Baker. White top, gully ash.

A tall tree with furrowed dark grey bark, smooth on the branches and upper bole. New South Wales, in the south coastal districts. Has recently been tried on the plains of northern India, but does not show much promise.

67. **Eucalyptus stellulata,** Sieb.

A small or moderate-sized tree with dense foliage and rough dark somewhat scaly bark, smooth and greenish on the branches. Wood a good fuel, but not much in request as timber. Victoria and New South Wales, along elevated river valleys or flats and on mountain sides up to the sub-alpine zone. Has recently been tried on the plains of northern India, but does not show much promise.

Eucalyptus stricta, Sieb., see 74. *E. virgata*, Sieb.

68. **Eucalyptus Stuartiana,** F. v. M. But-but, apple-scented gum, Stanthorpe box.

A small to moderate-sized tree with drooping branchlets, and often with a twisted stem ; bark persistent, fibrous, soft. Wood hard, tough, and durable. South Australia, Victoria, New South Wales, and Tasmania, on sandy and moist tracts, often on low ridges, sometimes on river flats, where it reaches a fair size ; Queensland, on poor ground. It is grown in the Nilgiris (Cairn Hill, block III), where, according to Mr. R. Bourne, several of the trees have been killed by cattle and deer, which tear off and eat the succulent bark. It has been tried in the Simla hills since 1909, and so far has done well between 4,000 and 7,000 ft., and moderately well below 4,000 ft. elevation. It has been tried on the plains of northern India, but has proved quite unsuitable.

69. **Eucalyptus tereticornis,** Smith. Grey gum, forest red gum.

A tall handsome tree. Bark smooth, whitish or greyish, more or less deciduous. Wood reddish, close grained, tough, and durable, used for building and many other purposes. Victoria, New South Wales, Queensland, never far from the littoral regions, and usually found on fertile ground on humid flats, around swamps and lakes, or along watercourses, never on saline ground or along salt-water streams ; stunted if found on rocky exposed localities. Under favourable conditions the growth is rapid. It does well on sandy soil, even if comparatively dry, but not on hard dry soil. In Florida trees have withstood temperatures of 20° and 22° F., but were frozen back at 19° F., although not permanently injured ; in California it is said to endure lower temperatures and to withstand drought well, while in Provence and Algeria it has grown well on low, marshy tracts where the soil is deep, and in Brazil on inundated soil where *E. rostrata* could not be grown successfully.[1] The tree coppices excellently. At Abbottabad coppice-shoots attained in one year a height of 15 ft. and a girth of 7½ in., and in 5½ years a girth of 22 in. At Dehra Dun the branches have been found rather liable to breakage by wind. Parker says it was severely damaged by frost at Abbottabad in 1905, but not so much as *E. Globulus* or many of the indigenous trees.

The tree has been grown in the Nilgiris ; Mr. Bourne mentions a specimen 6 ft. 2 in. in girth and 60 ft. high in Sim's Park, and adds that a whole planta-

[1] Zon and Briscoe, *loc. cit.*, p. 28.

tion of this species is said to have been planted by Mr. Gamble at the back of the Range Lodge, but either it died out or there was a mistake in identity. This species is probably the most successful one tried so far at low elevations in India, growing well even at Bombay. On the plains of northern India it is one of the best species, doing well in the United Provinces and the Punjab as far north as the Rawalpindi district, and also in Hazara. The growth is very rapid; of trees raised from seed sown about 1877 at Unah, Hoshiarpur district, measurements of some of the finest in 1893 (aged about sixteen years) were as follows: [1]

1.	Girth at 4 ft. from ground,	5 ft. 7 in.;	height, 115 ft.
2.	,, ,,	5 ft. 5 in.;	,, 115 ft.
3.	,, ,,	5 ft. 1 in.;	,, 115 ft.
4.	,, ,,	5 ft. 6 in.;	,, 75 ft.

Parker mentions a tree on poor gravelly soil near Haripur, Hazara, six years from seed, which measured 30 ft. in height and 2 ft. 5 in. in girth. There are a few good specimens in the Kaunli garden at Dehra Dun. It is the commonest species at Abbottabad. It has been tried in the Simla hills since 1909, and so far has done very well below 4,000 ft. and moderately well from 4,000 to 6,000 ft. It was tried in 1914 in the Andamans, and was one of the few species which showed any promise after the first year. Flowers January to April, Punjab (Parker).

70. **Eucalyptus trachyphloia,** F. v. M. White bloodwood.

A moderate-sized tree with dense foliage. Bark persistent, rough, fibrous, or almost woody inside. Wood hard, heavy, and durable. Southern Queensland, on poor hilly country, chiefly on sandstone. Said to be suitable as a shade tree in hot dry localities. Has been recently tried on the plains of northern India, but so far does not show much promise.

71. **Eucalyptus umbra,** R. T. Baker.

A tall tree with dark coloured stringy bark. Timber not very durable. New South Wales. It has recently been tried on the plains of northern India, but has not shown much promise.

72. **Eucalyptus urnigera,** Hook. f.

A small to moderate-sized tree with spreading branches and drooping branchlets. Bark smooth, pale brown. Tasmania, in alpine districts. It has recently been tried on the plains of northern India, but has proved quite unsuitable.

73. **Eucalyptus viminalis,** Labill. Manna gum.

A large handsome tree with drooping foliage. Bark partly persistent on the lower part of the stem, rough, wrinkled, and brownish, decorticating on the upper parts and on the branches, leaving the young smooth, bluish white bark, which when rubbed gives off a white powder. Wood fairly strong but not very durable, used for rough building, shingles, and rails. South Australia, Victoria, New South Wales, Tasmania, reaching large dimensions in deep forest glens, but found chiefly in open land, accommodating itself to poor and even sandy soil. It grows in the Nilgiris, sometimes attaining a fair size. Mr. R. Bourne gives the following distribution: (1) Sim's Park on lake

[1] W. Coldstream in Ind. Forester, xix (1893), p. 381.

edge; (2) below Cluny Hall; (3) some fine specimens at Snowdon Hall lining the Kotagiri road above the Snowdon ponds; (4) Sim's Park, compartment 1, above Forest Lodge. Measurements at Snowdon Hall gave girths of 8 ft., 9 ft. 6½ in., 10 ft. 7 in., and 13 ft. 4 in.; also girth 9 ft., height 124 ft. 6 in., girth 10 ft. 0½ in., height 128 ft. 6 in. It was tried without success about 1874–6 at Saugor, Central Provinces, and recently on the plains of northern India. It has been tried since 1909 in the Simla hills, and so far has done well at elevations of 4,000–7,000 ft. In Burma it has proved successful at low elevations.

74. **Eucalyptus virgata,** Sieb. Syn. *E. stricta,* Sieb.; *E. obtusifolia,* DC.

A large shrub, usually with very narrow leaves. New South Wales, ascending to high elevations in the mountains. Has been tried without success on the plains of northern India.

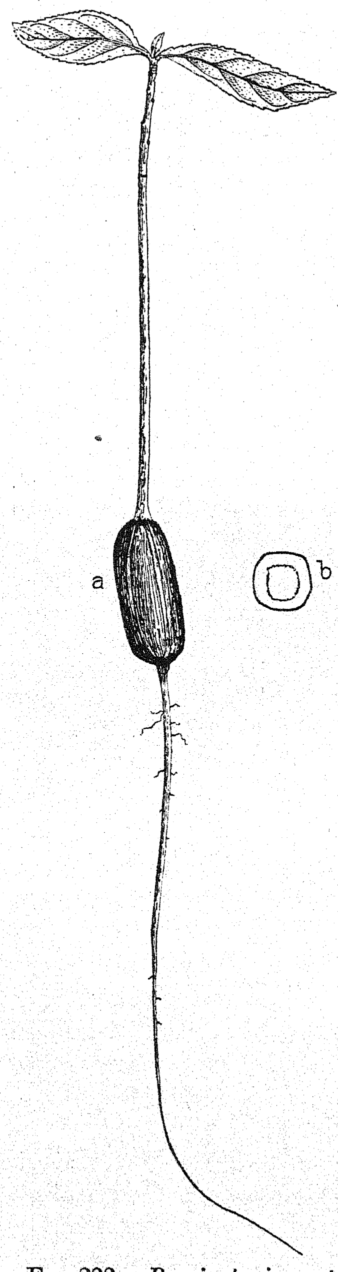

FIG. 222. *Barringtonia acutangula.* Seedling × ½. *a*, swollen hypocotyl; *b*, cross-section of hypocotyl.

3. BARRINGTONIA, Forst.

Species 1. *B. acutangula,* Gaertn.; 2. *B. racemosa,* Bl.

1. **Barringtonia acutangula,** Gaertn. Vern. *Injar, neora,* Hind.; *Hijal,* Beng.; *Tivar, piwar,* Mar.; *Kanapa,* Tel.; *Kyi, kyeni,* Burm.

A moderate-sized evergreen tree with dark rough bark, obovate leaves clustered at the ends of the branches, and long pendulous racemes of flowers with bright red stamens. The wood is used for boat-building, cabinet-making, and other purposes; the bark is rich in tannin, and is used to intoxicate fish. The tree is fairly common in many parts of India and Burma, in the sub-Himalayan tract from the Ganges eastwards, Bengal, Chota Nagpur, the Indian Peninsula, and Burma; also in Ceylon, the Malay Archipelago, and northern Australia. It is always found along the banks of streams, round the edges of swamps and in similar moist places. It is a familiar tree in the swamps of the sub-Himalayan tract, and is also common near the coast, though not found in mangrove swamps.

The leaves fall and the new leaves appear from February to April; the flowers appear chiefly from March to May, and the fruits ripen in July–August. The fruits are oblong, quadrangular, 1 in. or more in length, and about ½ in. in diameter. The seed is exalbuminous and solitary, and the embryo thick

and fleshy with rudimentary scale-like cotyledons. The fruits fall into the moist often muddy ground around the trees, and seedlings may be found in quantity growing in soft mud. Germination is peculiar. The shoot is developed from one end of the fleshy embryo and the root from the other end. A long taproot descends into the mud and the original fleshy portion of the embryo enclosed in the testa, and retaining the shape of the fruit, persists until the seedling attains a fair size. This fleshy portion resembles a tuber, and if cut across shows a ring of vascular tissue like that of a carrot (see Fig. 222). The function of this tuberous growth is presumably to store up nutriment in order to feed the young plant in the dry season when the mud dries up.

The tree is often planted for ornament. It is also suitable for planting in swampy ground where few other species will grow; probably direct sowings would prove most successful. It is ordinarily frost-hardy, but at Lahore it was slightly affected in the severe frost of 1905. In the abnormal drought of 1907 and 1908 it suffered along the banks of streams and swamps in Oudh when the water dried up.

2. **Barringtonia racemosa,** Bl.

A species with much larger flowers and fruits than the preceding. It also grows by streams and in swampy ground, and is indigenous along the west coast of the Indian Peninsula, in the Sundarbans, Andamans, Ceylon, the Malay Peninsula, and Polynesia.

4. CAREYA, Roxb.

Careya arborea, Roxb. Vern. *Kumb*, *kumbi*, Hind., Beng.; *Kumbia*, Mar.; *Kaval*, Kan.; *Ayama*, Tam.; *Gadava*, Tel.; *Banbwè*, Burm.

A moderate-sized to large deciduous tree with large obovate leaves clustered at the ends of the branches. Bark dark grey, fissured, red and fibrous inside. The wood is durable, especially under water, and is used for building, carts, furniture, &c.; the bark gives a good rough cordage fibre.

DISTRIBUTION AND HABITAT. The tree is found sporadically throughout the greater part of India and Burma, but not in the driest regions. It is very typical of savannah lands, where owing to its fire-resisting capacity it is able to survive and to regenerate, along with other fire-resisting species such as *Dillenia pentagyna*, *Eugenia operculata*, and *Bombax malabaricum*. When fire-protection is introduced more tender species take possession of the ground, but the old and often branchy savannah trees persist scattered in the new growth.

Careya arborea is a familiar tree in the sal forests and in the grassy blanks so common in them. In Burma it is commonest in the lower mixed forests of the plains and in the open savannah tracts. Generally it is characteristic of the moist types of mixed deciduous forest, and not of the drier types.

LEAF-SHEDDING, FLOWERING, AND FRUITING. The tree is leafless early in the hot season, the new leaves appearing in March–April. The leaves turn red in the cold season before falling. The clusters of large pink and white flowers appear with the new leaves in April–May, and the fruits ripen about June–July: they are green, globose, about 3 in. in diameter, containing several seeds embedded in a fleshy pulp, and fall soon after ripening. The seeds are exalbuminous, but have a large embryo similar in structure to that of *Barringtonia*: they often germinate within the fruit as it lies on the ground.

Silvicultural characters. The tree stands a fair amount of shade. In the abnormal drought of 1907 and 1908 in the sal forests of Oudh it proved to be decidedly hardy. It coppices well. It is very subject to damage by browsing, coppice-shoots in particular being greedily eaten by cattle and deer. As already noted, it is very fire-resistant.

Rate of growth. The following statistics regarding the rate of growth are available from sample plot measurements in sal forest :

Careya arborea : girth increment in high forest sample plots.

Province.	Forest division.	Locality.	No. of years under measurement.	No. of trees under measurement.	Girth classes.	Mean annual girth increment for period.
					ft.	in.
United Provinces	Saharanpur	Malowala	12	4	1–2	0·20
	Lansdowne	Chaukhamb	17	6	1½–8	0·32
	,,	Jogichaur	12	2	1½–3	0·18
	,,	Rehar	19	1	1½–3	0·05
Central Provinces	Balaghat	Baihar	8	1	1–2	0·44

Ring-countings by Mr. D. A. Thomson in respect of seventeen trees in the Supa fuel reserves, North Kanara, Bombay, gave the following results :[1]

Age in years . .	5	10	15	20	25	30	35	40	45	50	55	60	65
Mean diameter (inches)	1·05	2·02	3·07	4·09	5·08	5·90	6·84	7·74	8·46	9·38	10·14	10·94	11·71

Coppice-shoots grow fairly rapidly. Measurements in 1911 in two separate coupes, each two years old, in the Tikri forest, Gonda, United Provinces, showed average heights of 11 and 12 ft. as compared with 10 and 7·6 ft. respectively for sal in the same coupes. Measurements made in 1886 by Mr. A. F. Broun in two coupes, each eight years old, in the Bullawala coppice, Dehra Dun, gave the following results :

Careya arborea : growth of coppice, Bullawala, Dehra Dun.

Age.	Mean height. *Careya.*		Mean height. Sal.		Mean girth. *Careya.*	Mean girth. Sal.
years.	ft.	in.	ft.	in.	in.	in.
8	30	0	13	2·0	9·0	7·1
8	10	4	16	2·5	5·7	8·3

Mr. H. A. Gass recorded in 1898–9 an average height and girth of 10 ft. and 7 in. respectively, with nine shoots per stool, in a coppice coupe three years old in Kadike block, South Canara, Madras.

5. PLANCHONIA, Bl.

Planchonia andamanica, King.

An evergreen tree of the Andamans, occurring in evergreen or semi-deciduous forests in association with *Dipterocarpus* spp., *Hopea odorata, Mimusops Elengi, Artocarpus Chaplasha, Pterocarpus dalbergioides, Albizzia Lebbek, Terminalia bialata, Lagerstroemia hypoleuca,* and other species. The wood is hard, durable, and of good quality, and promises to become an important timber ; the tree deserves study from a silvicultural point of view.

[1] Working Plan for the Supa Fuel Reserves, 1906.

ORDER XXIX. LYTHRACEAE

This order contains a number of important Indian timber trees, chiefly belonging to the genus *Lagerstroemia*.

Genera 1. LAGERSTROEMIA, Linn.; 2. DUABANGA, Ham.; 3. SONNERATIA, Linn. f.; 4. WOODFORDIA, Salisb.; 5. PUNICA, Linn.

1. LAGERSTROEMIA, Linn.

This genus contains eleven Indian species of trees and perhaps a twelfth, *L. indica*, Linn., a well-known garden tree which is indigenous in China and possibly in the Shan hills in Upper Burma. To this genus belong some important Indian timber trees, most of which are very ornamental owing to their large showy flowers. The silviculture of these trees is at present imperfectly understood. The fruit is a capsule containing many winged, usually small light seeds, which, in all the species studied so far, are uncertain in their germinative power, a large proportion being as a rule unfertile. *L. indica* and *L. Flos-Reginae* are known to be capable of propagation from cuttings, and the same may possibly be the case with other species.

Species 1. *L. parviflora*, Roxb.; 2. *L. Flos-Reginae*, Retz.; 3. *L. tomentosa*, Presl.; 4. *L. lanceolata*, Wall.; 5. *L. macrocarpa*, Kurz; 6. *L. hypoleuca*, Kurz.

1. **Lagerstroemia parviflora,** Roxb. Vern. *Dhaura, lendia*, Hind.; *Sidha*, Hind., Beng.; *Lende, bondga*, Mar.; *Chenangi*, Tel.; *Zaungbalè, kyettawsa*, U. Burm.

A large, in poor localities a small, deciduous tree. Bark light grey to reddish, thin, smooth, exfoliating in narrow longitudinal flakes, light brown inside. Wood very hard, durable, used for building, agricultural implements, carts, boats, shafts, axe-handles, &c. The tree sometimes exhibits twisted fibre from left to right, and often produces burrs, especially when injured. Large trees are often hollow in the centre, and the timber has the fault of splitting a good deal near the centre. Apart from its economic value this tree is important silviculturally as a common companion of the sal, teak, and other valuable species.

DISTRIBUTION AND HABITAT. Sub-Himalayan tract from the Jumna eastwards, ascending to 3,000 ft., Bengal, Assam, Chota Nagpur, central India, and the Indian Peninsula southwards to the Nilgiris, Upper Burma. As a general rule the tree is not gregarious, though often plentiful. In the sub-Himalayan tract it is a common constituent of the sal forests, and is also plentiful on the dry waterless *bhabar* tract, a deep boulder formation along the base of the outer hills. Here the forest is often of a dry mixed type, and in the United Provinces among the chief associate species are *Adina cordifolia*, *Terminalia tomentosa*, *T. belerica*, *Hymenodictyon excelsum*, *Holoptelea integrifolia*, *Acacia Catechu*, and *Phyllanthus Emblica*. Farther east, in the Duars of Bengal and western Assam, it is one of the commonest trees along the base of the outer hills and on the dry boulder formation skirting them, the forest being of a dry character and the chief trees besides *Lagerstroemia* being *Shorea robusta*, *Terminalia Chebula*, *T. belerica*, *Phyllanthus Emblica*, *Sterculia villosa*, *Dillenia pentagyna*, *Bombax malabaricum*, *Gmelina arborea*, *Premna*, *Stereospermum*, and others, and near rivers *Dalbergia Sissoo* and *Acacia Catechu*.

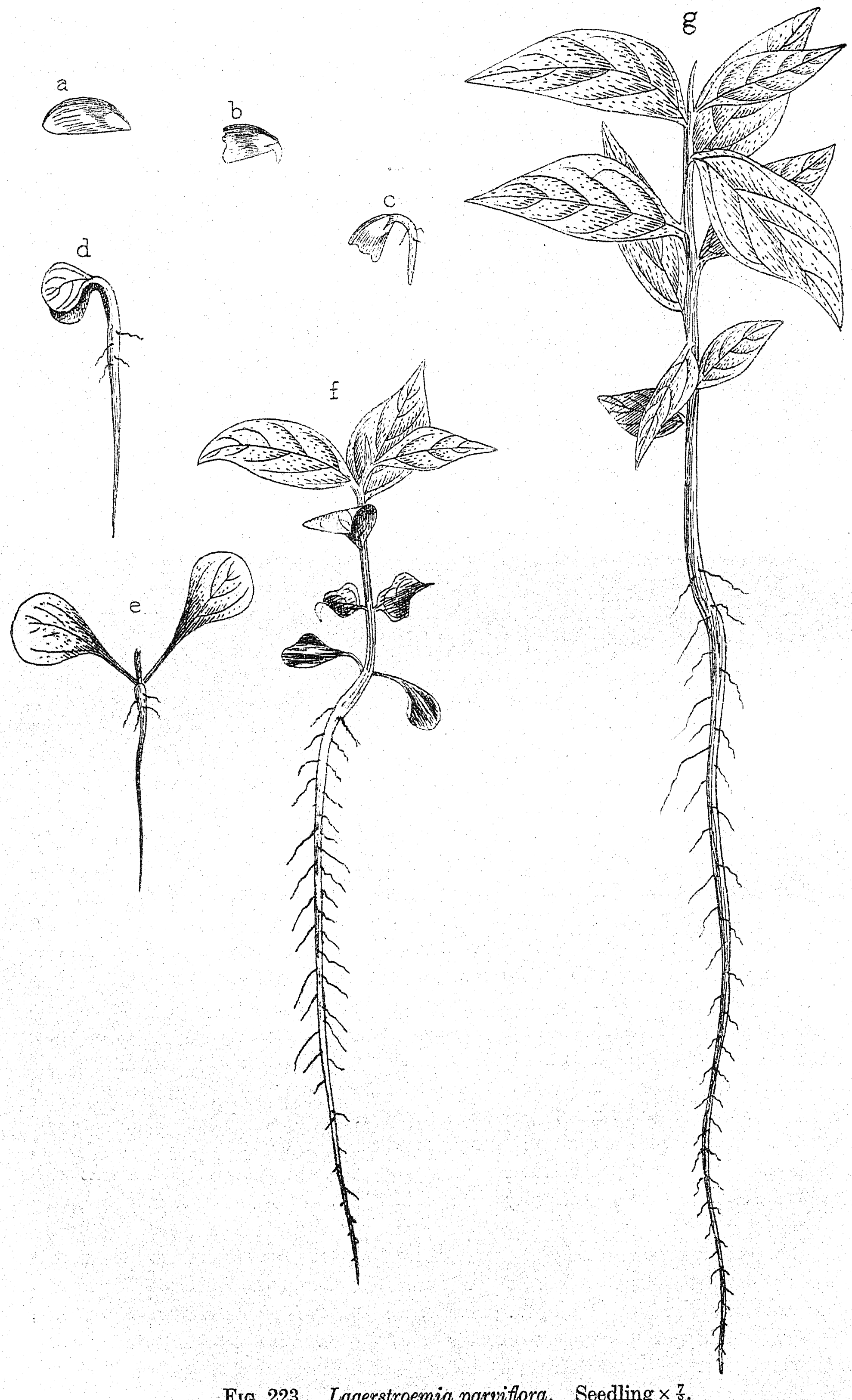

FIG. 223. *Lagerstroemia parviflora*. Seedling × $\frac{7}{8}$.
a, seed ; *b–e*, germination stages ; *f*, *g*, development of seedling during first season.

In these forests it attains considerable dimensions; a girth of 8 ft. 2 in. and a height of 100 ft. were measured in the Borojhar forest, Buxa, and this is by no means a maximum. In the *bhabar* tract of the Duars it sometimes springs up gregariously on gravel and boulder deposits near rivers, after the land has become elevated above river-level; here pure patches of young *Lagerstroemia*, sometimes of considerable extent, may be found with large specimens of *Dalbergia Sissoo* scattered among them, the latter being the survivors of a former riverain forest (see Fig. 224).

The tree is found in fair quantity throughout the dry mixed forests of the Indian Peninsula as far south as the Nilgiris, in association with teak, *Terminalia tomentosa*, *Anogeissus latifolia*, *Diospyros Melanoxylon*, *Ougeinia dalbergioides*, *Buchanania latifolia*, *Phyllanthus Emblica*, and other species. As a rule it does not attain large dimensions, trees over 6 ft. in girth being rare; in the Dangs forests of Surat, however, large trees are occasionally met with, a girth of 13 ft. having been recorded. In the Bori forest of the Central Provinces a girth of 15 ft. has been measured.

In Upper Burma it occurs in mixed deciduous forest along with teak, *Terminalia tomentosa*, *Dillenia pentagyna*, *Bursera serrata*, *Anogeissus acuminata*, *Schleichera trijuga*, *Lagerstroemia Flos-Reginae*, and other species.

The tree accommodates itself to a variety of soils and geological formations, including black cotton soil and trap; it thrives best on deep porous loam, and although it is often found on clay, it does not stand water-logging.

In its natural habitat the absolute maximum shade temperature varies from 100° to 118° F., the absolute minimum from 30° to 50° F., and the normal rainfall from 30 to 180 in.

Leaf-shedding, flowering, and fruiting. The leaves turn brown towards the end of the cold season and are shed in February–March, the new leaves appearing in April–May. The panicles of small white fragrant flowers appear from April to June, and the capsules ripen and open from December to February; they are 3- to 4-valved, 0·7–1 in. or more in length, ovoid or obovoid, brown when ripe, and remain some time on the tree after ripening. The seeds including wing (Fig. 223, *a*) are 0·4–0·6 in. long, brown, with a terminal papery wing, having a thick stiff curved ridge along one edge.

The germinative power of the seed is frequently poor. Tests were carried out at Dehra Dun for three successive years: in the first two years the seed was almost entirely unfertile, but in the third year it germinated well.

Germination (Fig. 223, *b–e*). Epigeous. The radicle emerges from the end of the seed opposite the wing, the hypocotyl arches and extricates the cotyledons in straightening, the seed-coat being left as a rule on or in the ground, though it is sometimes carried up over the cotyledons, falling with their expansion.

The seedling (Fig. 223).

Roots: primary root long, terete, tapering, wiry: lateral roots moderate in number and length, fibrous. *Hypocotyl* scarcely distinguishable, up to 0·1 in. long. *Cotyledons*: petiole 0·2–0·5 in. long, channelled above, glabrous: lamina 0·4–0·5 in. by 0·4–0·5 in., foliaceous, orbicular, base tapering, entire, green, glabrous. *Stem* erect, quadrangular, often winged, green or reddish, glabrous; internodes 0·1–0·5 in. long. *Leaves* simple, alternate, or first pair sometimes sub-opposite, sessile, exstipulate, 0·3–2 in. by 0·2–1 in., ovate

acuminate, base acute, entire, glabrous, margins minutely pubescent, venation arcuate, lateral veins 4–10 pairs.

The growth of the seedling is moderately fast. Young plants raised at Dehra Dun reached a height of 4 in. in two months, and 12 in. by the end of the year; on poor ground the growth is slower. For its best development the young plant requires a porous well-drained soil free from weeds. Young seedlings are very frost-tender, unlike coppice-shoots, which resist frost fairly well. They do not stand heavy shade or suppression from a dense growth of grass.

Silvicultural characters. The tree is a light-demander, and soon becomes suppressed under shade. It is fairly frost-hardy. In the abnormal drought of 1907 and 1908 in the forests of Oudh it proved to be decidedly hardy; saplings, however, were affected in the severe drought of 1899 and 1900 in the Central Provinces. Cattle avoid it, and on heavily grazed areas coppice-shoots often remain untouched after most of the other species have disappeared: sometimes the presence of pure *Lagerstroemia parviflora* may be the result of heavy grazing.

The tree coppices and pollards vigorously. Experiments were carried out in 1909 in North Chanda, Central Provinces, in which trees were coppiced in successive months from April to September; in no month did a single stool fail to coppice, a result not attained by any other species experimented with. Again, Mr. A. E. Osmaston [1] records complete success in the case of 25 trees coppiced in experiments in the Gorakhpur district, United Provinces. The following numbers of shoots per stool have been measured in the United Provinces:

1. Gorakhpur district: age one to sixteen years; average 1·6 to 3·2 shoots per stool.
2. Gonda district: age one and two years; average 1·7 to 2·7 shoots per stool.

Natural reproduction. The natural reproduction of this tree requires further study. As far as is known, fertile seed is not produced in abundance every year, though in certain years reproduction springs up in quantity. Loose porous bare soil appears to favour natural reproduction, which often comes up readily on abandoned cultivation on well-drained ground, and on riverain alluvial gravel which has risen above river-level. Immunity from damage by grazing and good power of recovery from the effects of fire and mutilation are factors which favour the natural reproduction of this species; the admission of light also stimulates it.

Silvicultural treatment. As a rule this tree is treated as an accessory to species of greater value, such as teak or sal, and its treatment is subordinated to that of the principal species. It is eminently adapted for working as coppice, a rotation of thirty years being generally sufficient for the production of poles for building purposes.

Rate of growth. 1. *High forest.* The following results of girth measurements in sample plots are available:

[1] Ind. Forester, xxxvii (1911), p. 429.

FIG. 224. Former riverain forest of *Dalbergia Sissoo* in process of conversion to forest of *Lagerstroemia parviflora*; large tree of former species surrounded by pure sapling growth of latter, Goalpara, Assam.

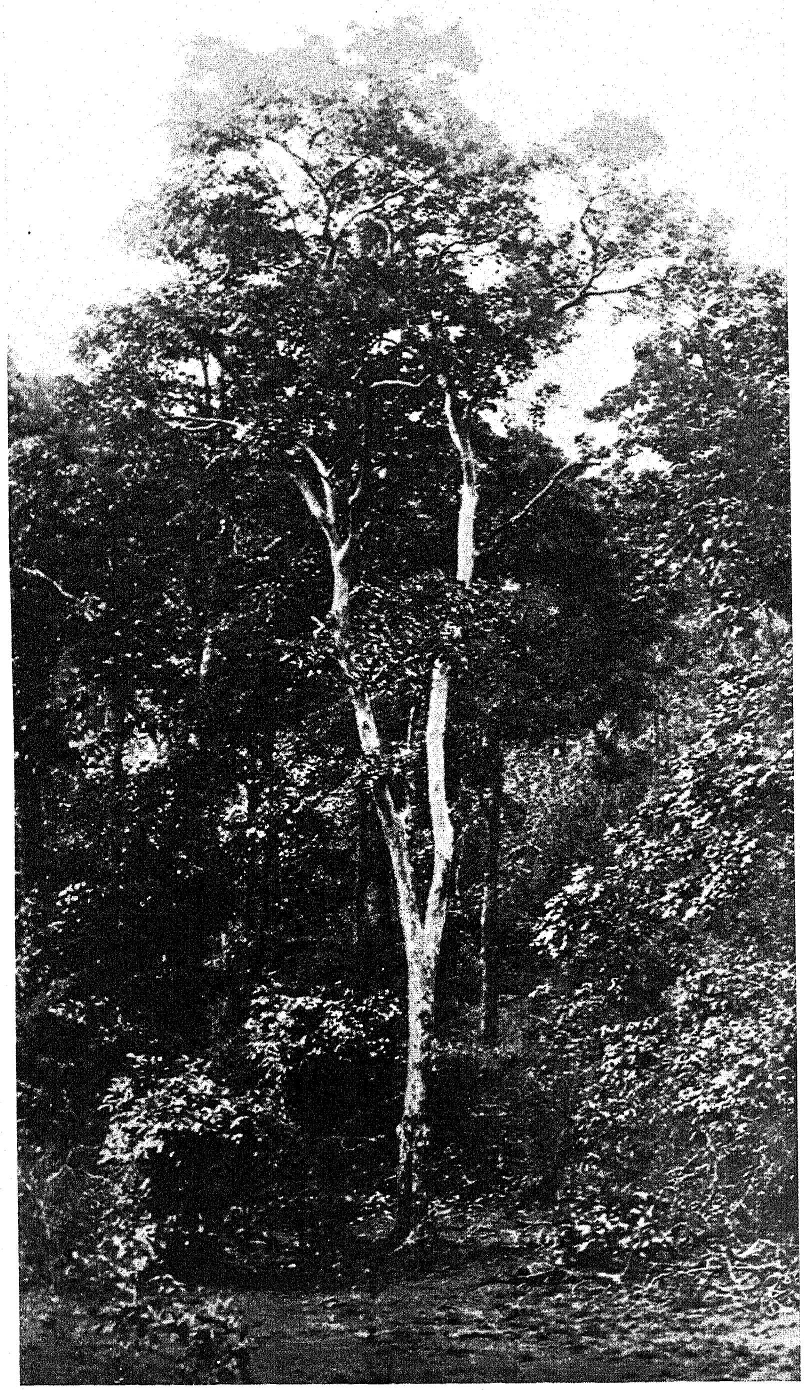

FIG. 225. *Lagerstroemia lanceolata*, Bombay.

Lagerstroemia parviflora: girth increment in high forest sample plots.

Province.	Forest division.	Locality.	Number of years under measurement.	Number of trees under measurement.	Girth classes. ft.	Mean annual girth increment for period. in.
United Provinces	Dehra Dun	Thano and Kansrao	17	3	1–2	0·13
				1	2–3	0·30
	Saharanpur	Dholkhand, Lakarkot, Malowala	..	5	0–1	0·23
				32	1–2	0·23
				4	2–3	0·34
	Lansdowne	Andermajhera	17	12	0–4	0·11
		Kauria	4	3	1½–3	0·14
	Haldwani	Aonla Khera	4	1	0–1½	0·40
		Chilla	11	4	3–6	0·34
		Khonani	6	5	1½–6	0·31
	S. Kheri	Kishanpur	9	2	2–3	0·10
Central Provinces	Balaghat	Raigarh	8	1	1–2	0·09
				1	2–3	0·03

These figures indicate a decidedly slow rate of growth. The sample plots in question, however, are all in sal forest, and presumably many of the *Lagerstroemia* trees are dominated or even suppressed.

The following rate of growth has been deduced from measurements of 41 trees in the Dholkhand, Lakarkot, and Malowala sal sample plots, Saharanpur forest division, United Provinces, and of 22 trees scattered in sal sample plots in the Buxa forest division, Bengal :

Lagerstroemia parviflora: rate of growth in high forest, Saharanpur and Buxa divisions.

Age. years.	Girth. Saharanpur. ft. in.	Girth. Buxa. ft. in.	Age. years.	Girth. Saharanpur. ft. in.	Girth. Buxa. ft. in.
20	..	0 10	100	1 11	4 1
30	0 7	1 3	110	2 1½	4 6
40	0 9	1 8	120	2 5	4 11
50	0 11½	2 0	130	2 8½	5 4
60	1 2	2 5	140	3 0	5 8
70	1 4½	2 10	150	..	6 1
80	1 6½	3 3	160	..	6 6
90	1 9	3 8			

A cross-section 4 ft. 6 in. in girth in the silvicultural museum, Dehra Dun, had 56 rings, giving a mean annual girth increment of 0·96 in.

2. *Coppice.* The rate of growth of *Lagerstroemia parviflora* coppice is at first usually more rapid than that of sal, but the latter afterwards outgrows the former. The following are some recorded measurements of young coppice-shoots :

Lagerstroemia parviflora: rate of growth of young coppice, compared with sal or teak in the same coupes.

Locality.	Age. years.	Height. *Lagerstroemia parviflora.* ft.	Height. Sal. ft.	Height. Teak. ft.
Gonda, United Provinces . .	1	6·8	4·7	..
	2	10·3	10·0	..
	2	9·5	7·6	
Gorakhpur, United Provinces .	1	7·8	4·5	..
	1	7·3	2·8	..
	3	9·1	9·7	..
Thano, Dehra Dun, United Provinces	5	15·0[1]	..	..
Bhandara, Central Provinces . .	1	6·3	..	7·1

[1] Mean girth 6 in.

Mr. A. F. Broun recorded the following measurements made in 1886 in coppice coupes at Bullawala, Dehra Dun:

Lagerstroemia parviflora: rate of growth of coppice, Bullawala, Dehra Dun.

	Mean height.		Mean girth.	
Age.	*Lagerstroemia parviflora.*	Sal.	*Lagerstroemia parviflora.*	Sal.
years.	ft. in.	ft. in.	in.	in.
8	19 1·1	13 1·9	6·2	7·1
8	15 4·2	16 2·5	6·4	8·3
10	18 6·0	11 10·6	6·0	5·9

The results of measurements made by Mr. C. M. McCrie in 1910 in coppice coupes in the Gorakhpur district, United Provinces, are shown as follows:

Lagerstroemia parviflora: rate of growth of coppice, Gorakhpur.

	Mean height.		Mean girth.	
Age.	*Lagerstroemia parviflora.*	Sal.	*Lagerstroemia parviflora.*	Sal.
years.	ft.	ft.	in.	in.
2	6·8	3·0	—	—
4	9·8	7·0	3·9	2·0
6	12·3	10·3	4·8	2·9
8	14·5	13·0	5·4	3·8
10	16·4	15·3	6·0	4·8
12	18·0	17·5	6·5	5·8
14	19·4	19·2	6·9	6·7
16	20·5	20·9	7·2	7·5

2. **Lagerstroemia Flos-Reginae,** Retz. Syn. *L. speciosa*, Pers. Vern. *Jarul*, Beng.; *Ajhar*, Ass.; *Taman, bondara*, Mar.; *Hole-dasal, challa*, Kan.; *Pumarathu*, Tam.; *Manimarathu*, Mal.; *Pyinma*, Burm.; *Eikmwè*, U. Burm.

A large deciduous tree with a rounded crown and large handsome mauve flowers. Bark smooth, grey or yellowish grey, exfoliating in fairly thin irregular flakes. Wood light red, hard, durable, used for construction, boat-building, canoes, carts, and other purposes. This is one of the most important timber trees of Burma and Assam.

Distribution and habitat. Assam, Bengal, Chittagong, western and southern India from North Kanara and the southern Konkan southwards through Malabar to Travancore, Chota Nagpur (not very common, and of small size). Common throughout Burma, but not in the dry zone; Ceylon, in the moist low country. In the sub-Himalayan tract the tree is not considered to be indigenous west of Bengal, but it is certainly plentiful, though of comparatively small size, along the banks and within some little distance of certain streams in forest lands in the Gorakhpur district, United Provinces, and if not indigenous it has at all events run wild. It is planted for ornament in many parts of India.

The tree is typically found along the banks of rivers and streams and on low-lying swampy ground. It is not, however, always confined to such places, for in Burma it is often scattered in the moister types of lower mixed deciduous forest on alluvial ground and sometimes in evergreen forest: in the upper mixed forests it is usually confined to the banks of streams and to alluvial flats in their neighbourhood. Its growth is best on rich deep alluvial loam: on badly-drained swampy ground it is usually small and crooked.

FIG. 226. *Lagerstroemia Flos-Reginae*—SEEDLING $\frac{1}{1}$

a—Fruit b—Seed c - f—Germination stages g - i—Development of seedling during first season

In its natural habitat the absolute maximum shade temperature varies from 95° to 110° F., the absolute minimum from 36° to 65° F., and the normal rainfall from 60 (about 50 in Gorakhpur) to 180 in. or more.

LEAF-SHEDDING, FLOWERING, AND FRUITING. The tree sheds its leaves about February–March, the leaves turning reddish before falling; the new leaves appear in April–May. The large terminal panicles of mauve flowers, 2–3 in. in diameter, appear from April to June, at which time the trees are extremely handsome. The capsules (Fig. 226, *a*), 5- to 6-valved, broadly ovoid, 0·7–1 in. long, ripen from November to January, according to locality, though they do not actually open and scatter the seeds for some little time (February, Goalpara, Assam, 1915; March–April, Dehra Dun, planted trees). The seeds (Fig. 226, *b*) are light brown, angular, fairly hard, with a stiff brittle wing, the whole 0·6–0·7 in. long; they are often unfertile. The tree seeds at an early age; vigorous plants raised from irrigated broadcast sowings at Dehra Dun commenced to bear seed at the age of three years.

GERMINATION (Fig. 226, *c–f*). Epigeous. The radicle emerges from the end of the seed opposite the wing; the hypocotyl arches slightly and extricates the cotyledons in straightening. The seed-coat is left on or in the ground.

THE SEEDLING (Fig. 226).

Roots: primary root moderately long, wiry, flexuose, thick in vigorous plants: lateral roots numerous, long, fibrous. *Hypocotyl* distinct from root, 0·4–0·7 in. long, quadrangular, reddish or green, glabrous. *Cotyledons*: petiole 0·05 in. long: lamina 1·5–2 in. by 2–2·5 in., foliaceous, somewhat fleshy, orbicular reniform, broader than long, apex truncate or slightly retuse, entire, glabrous. *Stem* erect, 3- to 5-angled and winged, woody, glabrous, young parts green or reddish, older parts greenish brown; internodes 0·1–1·3 in. long. *Leaves* simple, alternate, sessile or sub-sessile, exstipulate, earlier leaves small, the size increasing with successive leaves, 0·5–2·5 in. by 0·3–1·5 in. in natural seedlings, up to 8 by 3 in. in vigorous artificially grown seedlings, elliptical or elliptical lanceolate or obovate, acute or acuminate, base acute, entire or undulate, glabrous, paler beneath than above, venation arched, with a prominent intramarginal vein, midrib often reddish, veins prominent, raised on under side.

During the first season the growth of the seedling is slow, a height of only 2–6 in. being ordinarily attained by the end of the year; subsequently the growth is considerably faster. Weeding and irrigation, particularly the former, greatly stimulate growth. Plants raised from weeded broadcast sowings on tilled ground at Dehra Dun reached in three years a height of 10 ft. when irrigated, and 8 ft. when not irrigated. In the first year they attained a height up to 3 ft. The leaves fall about November to January, and new growth starts in March (Dehra Dun). In their earlier stages the seedlings are small and delicate, and are apt to be washed away by heavy rain; they are sensitive to frost and drought.

SILVICULTURAL CHARACTERS. The tree is a moderate light-demander, soon becoming suppressed under shade which is at all heavy; it is less light-demanding than teak. In its natural habitat it is exposed neither to frost nor ordinarily to drought: in the severe frost of 1905 trees planted at Dehra Dun suffered. It is a decidedly moisture-loving tree. It coppices well, the coppice-shoots growing vigorously.

NATURAL REPRODUCTION. Under natural conditions the seeds lie on the ground during part of the hot season and often become washed into heaps during the early showers. Germination takes place early in the rainy season. The factors influencing natural reproduction require further study, but experiments carried out so far indicate that bare loose soil is favourable, and that weed-growth is most unfavourable. For the establishment of natural reproduction a considerable amount of light is required. The sensitiveness of young seedlings to drought has been alluded to. The prevalence of natural reproduction round the edges of swamps and along the sides of watercourses is probably due mainly to the fact that the seeds are washed together in quantity on the bare ground, and the seedlings develop well under the conditions of light and soil moisture which they enjoy. Good natural reproduction is reported to have appeared in the Yetkanzin forest, Toungoo, Burma, in an area where bamboos had flowered, which had been fire-protected for many years and then burnt after the flowering of the bamboos.[1]

ARTIFICIAL REPRODUCTION. Owing to the lightness of the seed and the small size of the young seedlings, direct sowings are less suitable than transplanting from the nursery. Broadcast sowings on cleared and hoed ground at Dehra Dun have, however, proved successful on an experimental scale. A fair amount of planting has been done within recent years in Assam, notably in Lakhimpur. Direct sowings in lines 6 ft. apart were carried out between 1876–7 and 1882–3 in the Nambor forest, Sibsagar, Assam, the *Lagerstroemia* being mixed with *Mesua ferrea*. In 1903 the area was found to be very densely stocked with young poles of both species, in which the *Lagerstroemia* greatly outnumbered the *Mesua*.[2] Transplanting after pruning the roots has been tried without success in Sibsagar.

Mr. R. Bourne informs me that in Malabar he obtained the best results in germination by sowing the seeds in flat beds divided into squares surrounded by small mud walls, so that when the beds were flooded the water stood in them for some time.

RATE OF GROWTH. There are few reliable statistics showing the rate of growth. The following heights of young plants are recorded in different plantations in the Jokai reserve, Lakhimpur, Assam: [3]

Age (exclusive of time in nursery)	Average height. ft.
Year of planting	6
1 year	7
2 years	10
3 years	9

A few trees planted at Kuch Behar in 1873–4 had attained in 1881 a maximum girth of 2 ft. 4 in. with a height of 16 ft. The locality was reported to be unsuitable, the trees having developed a low shrubby growth.[4]

The Rangoon plains forests working plan[5] gives an estimate of the rate of growth based on ring-countings, the results being as follows:

[1] Burma Forest Report, 1914–15.

[2] Working Plan for the Nambor Reserved Forest, Sibsagar, A. R. Dicks, 1905.

[3] Forest Report, 1913–14.

[4] W. R. F. in Ind. Forester, vii (1881–2), p. 41.

[5] Working Plan for the Plains Forests, Rangoon Division, Burma, J. J. Rorie, 1905.

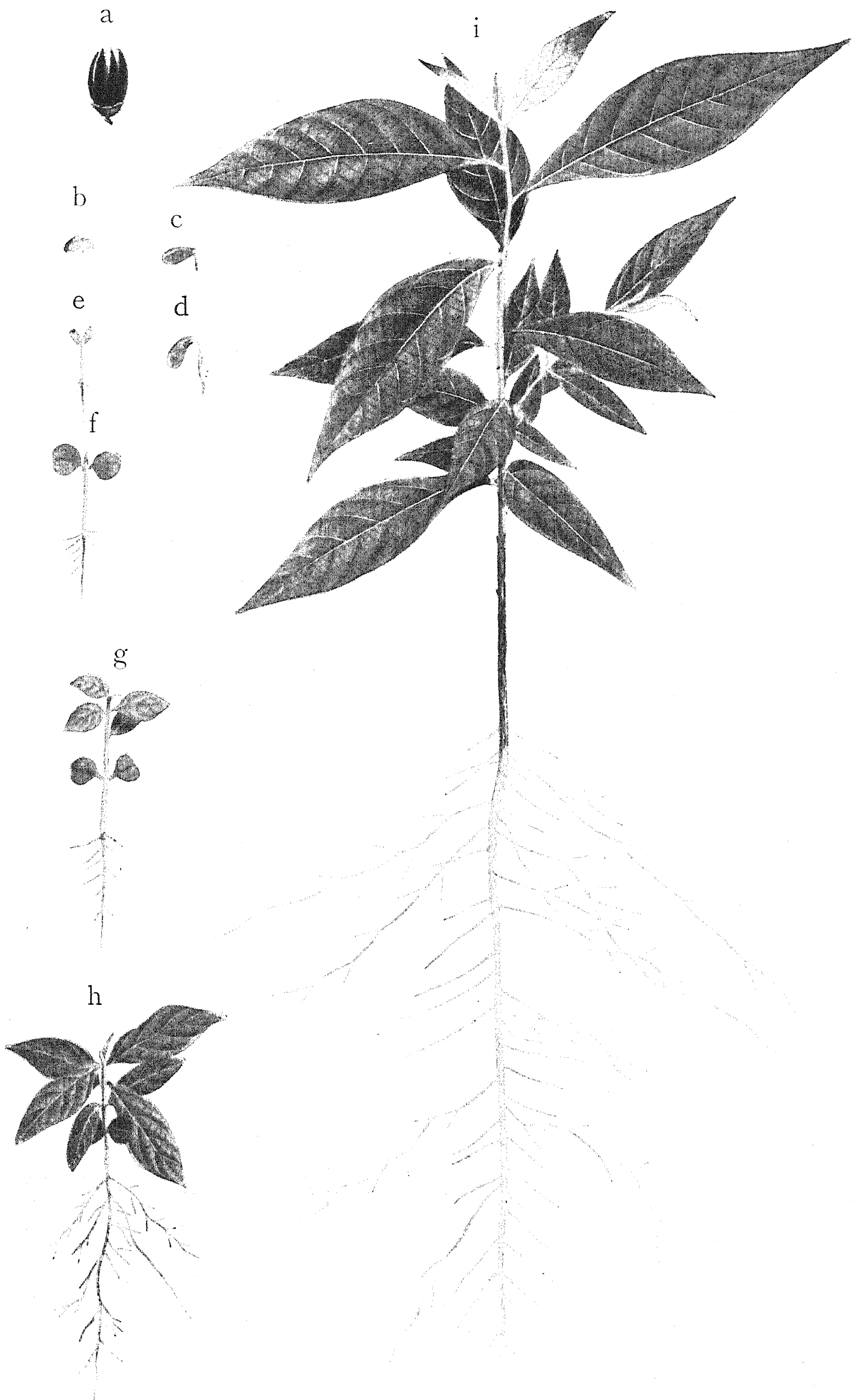

FIG. 227. *Lagerstroemia tomentosa*—SEEDLING × $\frac{5}{8}$

a—Fruit b—Seed c-f—Germination stages g, h—Development of seedling during first season
i—Seedling in second season

Girth.		Corresponding age.
ft.	in.	years.
1	6	36
3	0	63
4	6	94
6	0	125

The mean annual girth increment, 0·576 in., is identical with that estimated for teak growing in the same forests.

3. **Lagerstroemia tomentosa,** Presl. Vern. *Lèza*, Burm.

A large deciduous tree, reaching a height of 100 ft. or more, and a girth of 10 to 12 ft. or more in favourable localities. Bole usually straight and clean to a considerable height. Bark about 0·3–0·4 in. thick, light grey, fairly smooth, with longitudinal cracks. Wood light grey to greyish brown, moderately hard, close grained, fairly durable, used for planking, building, canoes, carts, shafts, wheels, and furniture, and deserving of more notice for boxes and such purposes. It has been tested and reported suitable for match manufacture.

Distribution and habitat. The tree is common throughout the greater part of Burma, except in the dry zone. It is found in evergreen and semi-evergreen tropical forest, and in mixed deciduous forest of the upper and lower types. In the upper mixed forests it is associated with teak, *Xylia dolabriformis*, and their common companions, usually occupying the lower slopes of hills and well-drained valleys on deep rich soil; in the drier types of mixed forest it is either absent or is found in stunted form. In the lower mixed forests on alluvial ground it is sometimes very plentiful, particularly in some localities along the base of the eastern slopes of the Pegu Yoma.

In its natural habitat the absolute maximum shade temperature varies from 100° to 110° F., the absolute minimum from 40° to 55° F., and the normal rainfall from 40 to 200 in.

Leaf-shedding, flowering, and fruiting. The tree is leafless for a time in the hot season. The panicles of handsome white flowers, 1–1·3 in. in diameter, appear in April–May, and the capsules (Fig. 227, *a*) commence to ripen about November, dehiscing at various times up till April; they are ovoid, 0·5–0·6 in. long, dark brown when ripe. The light winged seeds (Fig. 227, *b*) are about 0·3 in. long; they escape from the capsules chiefly during the hot season and are carried by wind to some distance from the tree. Like that of other species of this genus, the fertility of the seed is uncertain. Tests carried out at Dehra Dun showed that the seed retains its vitality to some extent for one year if carefully stored. At Peradeniya, Ceylon, where the tree was introduced in 1891, flowering takes place twice a year, in April and October; this may also be the case sometimes in Burma.

Germination (Fig. 227, *c–f*). Epigeous. The radicle emerges from the end of the seed opposite the wing, the hypocotyl arches somewhat, and the seed-coat is either left in or on the ground or is carried up, falling with the expansion of the cotyledons.

The seedling (Fig. 227).

Roots: primary root moderately long and thick, terete, tapering, woody: lateral roots numerous, long, fibrous. *Hypocotyl* distinct from root, 0·3–0·5 in. long, quadrangular, glabrous. *Cotyledons*: petiole up to 0·06 in. long: lamina 0·2–0·3 in. by 0·25–0·3 in., foliaceous, sub-orbicular or broadly obovate, apex rounded, truncate or retuse, base tapering, entire, green. *Stem* erect, quad-

rangular, stellate tomentose; internodes 0·1–0·6 in. long. *Leaves* simple, exstipulate, first pair opposite, subsequent leaves on main stem alternate, sometimes sub-opposite, those on side branches opposite or sub-opposite. Petiole 0·1 in. long, stellate tomentose. Lamina 0·8–3·2 in. by 0·3–1·3 in., elliptical lanceolate, acuminate, base tapering, entire, stellate pubescent.

During the first season the seedling remains comparatively small, but from the second year onwards the growth is fairly fast. Seedlings raised in a box at Dehra Dun were 1 ft. 6 in. to 2 ft. 7 in. in height by the middle of the second season, and one of these which was transplanted reached a height of 9 ft. 7 in., with a basal girth of 7½ in. by the end of the fourth season. These seedlings for the first two or three years developed long thin weak stems and had the habit of climbers rather than of erect plants; eventually, however, they became rigid and erect. The young seedlings are sensitive to drought; frost is unknown in the natural habitat of the tree, but at Dehra Dun the young seedlings proved to be very sensitive to frost, and all those grown in the open succumbed during the first winter.

NATURAL REPRODUCTION. The seeds fall during the hot season, and are washed into heaps by the early showers. Germination takes place at the beginning of the rainy season. The factors influencing natural reproduction require further study, but experiments at Dehra Dun indicate that bare loose moist soil is favourable to germination, and that stiff soil and weed-growth are unfavourable; also that in early youth shade is beneficial in preventing mortality through drought. These experiments, however, are not conclusive, more especially as climatic conditions at Dehra Dun are very different from those met with in the natural habitat of the tree.

ARTIFICIAL REPRODUCTION. Experiments at Dehra Dun showed that young plants can best be raised on well-drained porous soil kept moist and protected from the sun. Transplanting can be carried out without much difficulty in the second rainy season. No plantations of this species, so far as is known, have ever been made. A young tree in the Forest Research Institute grounds, Dehra Dun, raised from seed sown in 1912, shows good promise.

4. **Lagerstroemia lanceolata,** Wall. Syn. *L. microcarpa*, Wight. Benteak. Vern. *Nana*, Mar.; *Nandi, bili-nandi*, Kan.; *Ventek*, Tam. (Fig. 225.)

A large deciduous tree with smooth whitish bark exfoliating in large papery strips. Wood moderately hard, used for building, furniture, boxes, &c. A valuable timber, but liable to split and not durable in the open.

DISTRIBUTION AND HABITAT. This is one of the most important trees of the west coast of the Indian Peninsula, where it is very common along and below the Western Ghats from Bombay southwards to Travancore, ascending the hill ranges of Coorg, Mysore, and Travancore, and the Nilgiris and other hills, to 4,000 ft. In East Khandesh it is rare, and in Kolaba and Surat is only scattered.

In its natural habitat the absolute maximum shade temperature varies from 95° to 115° F., the absolute minimum from 43° to 63° F., and the normal rainfall from 30 to 180 in. or more. It attains its best development in regions of heavy rainfall, for instance in Kanara, Malabar, and Coorg, where it reaches a large size. It grows well both on hill slopes and in valleys, preferring crystalline rocks to laterite. It is found most commonly in mixed deciduous forests associated with teak, *Terminalia tomentosa, T. paniculata, Xylia xylocarpa, Dalbergia latifolia, Pterocarpus Marsupium, Adina cordifolia*, and other species.

It occurs also in evergreen forest, but usually in the form of large trees surviving from a former deciduous forest into which the evergreen species have encroached.

LEAF-SHEDDING, FLOWERING, AND FRUITING. The tree is leafless for a time in the hot season. The small white flowers appear from April to June, and the fruits ripen in the cold season. The small light seeds fall early in the hot season and germinate at the beginning of the rains: they are carried by the winds to some distance from the tree. Mr. H. Tireman mentions that he has twice tried to raise seedlings in Coorg, but on neither occasion did any seed germinate: this would indicate that the germinative power, like that of other species of this genus, is uncertain.

SILVICULTURE AND NATURAL REPRODUCTION. The factors influencing natural reproduction require further study. So far as is known the seedlings do not stand exposure to a hot sun, and benefit by slight shade, while they require a fair amount of moisture in the soil. Bare loose soil aids natural reproduction, which appears freely on abandoned cultivation. The seedling is capable of bearing considerable shade, but later the tree benefits by an abundance of light, though it is less light-demanding than teak. Fire does not appear to do much harm to reproduction, though it produces hollows at the bases of the trees. In the moister types of forest fire-protection has had an adverse effect in encouraging the growth of dense evergreen vegetation which has prevented the reproduction of this and other light-demanding deciduous trees. Mr. H. Tireman notes that the limited amount of grazing in Coorg is beneficial in keeping down undergrowth and favouring natural reproduction. The tree coppices well.

RATE OF GROWTH. 1. *High forest.* The following table has been compiled from measurements, based on ring-countings, recorded in high forest working plans in the North Kanara district, Bombay:

Lagerstroemia lanceolata: rate of growth in diameter in high forests of the North Kanara district, Bombay.

Age.	Supa fuel reserves.[1] (1906)	Ankola high forest.[2] (1908)	Kalinaddi slopes.[3] (1909)	Sopinhosalli high forest.[3] (1910)	Ankola-Kumta coast.[3] (1911)	Sirsi town forests.[3] (1913)	Yekambi Sonda high forest.[3] (1914)
years.	in.	in.	in.	in.	in.	in.	in.
10	2·2	2·7	2·9	1·8	2·0	1·1	1·3
20	4·4	4·9	5·3	3·6	4·8	2·4	3·2
30	6·7	6·7	7·5	5·3	7·2	3·8	5·5
40	8·9	8·5	9·7	7·1	9·3	5·3	7·8
50	10·8	10·3	11·9	9·0	11·4	6·9	10·0
60	12·2	11·9	14·2	10·9	..	8·2	11·8
70	13·2	13·3	15·9	12·8	..	9·7	13·4
80	13·7	14·8	17·5	14·5	..	11·2	15·0
90	..	16·2	19·0	16·2	..	12·6	16·4
100	..	17·5	20·3	17·8	..	13·8	17·8
110	..	18·6	21·7	19·3	..	15·0	19·1
120	..	19·6	22·9	20·8	..	16·1	20·3
130	..	20·6	23·9	..	..	17·2	21·4
140	..	21·5	25·0	..	..	18·3	22·5
150	..	22·4	25·9	..	..	19·4	23·6
160	..	23·2	26·8	..	..	20·5	24·6
170	..	24·0	27·5	..	..	21·6	25·6
180	..	24·7	28·2	..	..	..	..

Note.—Diameter excludes bark: average bark thickness 0·33 in. in Ankola, 0·3 in. in Kalinaddi slopes and Sopinhosalli.

[1] Measurements by D. A. Thomson. [2] Measurements by R. S. Pearson.
[3] Measurements by P. E. Aitchison.

Mr. H. Tireman has recorded the following measurements, made in 1916, of trees which sprang up in two teak plantations in Coorg, formed in 1884 and 1891, and therefore 32 and 25 years old respectively :

Plantation of 1884.			Plantation of 1891.		
Height.	Girth at breast height.		Height.	Girth at breast height.	
ft.	ft.	in.	ft.	ft.	in.
(1) 65	2	9	(1) 50	2	5
(2) 61	2	8	(2) 49	2	6
(3) 60	2	8	(3) 48	2	8
(4) 58	1	10	(4) 47	2	7
(5) 51	1	10	(5) 45	2	2
(6) 50	2	10	(6) 45	1	10

Since the age of these trees cannot be greater than that of the plantations, the mean annual girth increments would be at least 0·91 and 1·13 in. in the two plantations respectively.

Measurements in North Malabar gave the following results :

Average age at	6 in.	diameter	28	years.
,, ,,	12 ,,	,,	50	,,
,, ,,	18 ,,	,,	72	,,
,, ,,	24 ,,	,,	103	,,

Gamble's specimens gave six to eight rings per inch of radius, representing a mean annual girth increment of 0·78 to 1·05 in.

2. *Coppice.* Mr. H. Murray records the following measurements of coppice-shoots in Belgaum :

Age.	Height.	Diameter.
years.	ft.	in.
5	10·5	2·3
10	19·0	3·6
15	23·0	4·6
20	27·5	5·8
25	31·5	6·9
30	34·5	8·0
35	37·0	9·0
40	39·0	9·75

5. **Lagerstroemia macrocarpa,** Wall. Vern. *Kônpyinma*, Burm.

A moderate-sized tree, somewhat resembling *L. Flos-Reginae*, but with larger leaves and flowers. The latter are 3 in. or more in diameter, and the tree is extremely handsome when in flower in the hot season. This species is most commonly found in the plains forests and on cultivated lands, often in rather low bushy form ; it is usually confined to moist or even swampy situations.

6. **Lagerstroemia hypoleuca,** Kurz. Vern. *Pyinma*, Burm. (in Andamans) ; *Pábdá*, And.

A large deciduous tree with thin whitish bark. Wood hard, durable, used for building, shingles, wheel-work, and other purposes ; apt to split in seasoning. This is one of the principal species of the Andamans, where it occurs chiefly in deciduous forests associated with *Pterocarpus dalbergioides*, *Terminalia bialata*, *T. Manii*, *T. Catappa*, *Odina Wodier*, *Bombax insigne*, *Albizzia Lebbek*, *Adenanthera pavonina*, *Sterculia* spp., and others. *Lagerstroemia hypoleuca* is found usually on sandy soil on low ground, and is less common in the hills. It extends into evergreen forest, where it is associated

FIG. 228 *Duabanga sonneratioides*—SEEDLING × $\frac{1}{2}$

a—Seed × 5 b - d—Germination stages (b and c × 5, d × $2\frac{1}{2}$) e, f—Development of seedling during first season × $1\frac{1}{2}$ g - i—Development of seedling during second season × $\frac{1}{2}$

with various species of *Dipterocarpus* and other trees. Mr. C. G. Rogers[1] notes that the tree seeds freely nearly every year, and the seeds germinate easily; on Wilson Island he mentions that natural reproduction in very open forest is remarkably good, extensive thickets of this species being found. Mr. F. H. Todd[2] notes that natural reproduction is good in the North Andaman. Flowers June–July; fruits cold season (Kurz).

2. DUABANGA, Ham.

Duabanga sonneratioides, Ham. Vern. *Lampatia*, Nep.; *Khokan*, Ass.; *Myaukngo*, *Mau-lettanshe*, Burm. (Fig. 229.)

A large deciduous tree with characteristic long horizontal branches drooping at the ends, and opposite large sessile leaves. Bark greyish brown, peeling off in thin flakes. Under forest conditions the tree forms a long clean bole. Sometimes it attains a very large girth; Mr. J. W. A. Grieve measured a tree 18 ft. in girth in the Tista valley. Wood grey or yellowish grey, soft, seasoning well without warping or splitting, excellent for tea-boxes, for which it is largely used; also used for canoes, and has been reported on as a good wood for match manufacture. As a fast-growing useful softwood this tree is well worth more attention.

Distribution and habitat. Eastern sub-Himalayan tract, ascending to 3,000 ft., Assam, Manipur, Chittagong, Burma, Andamans, and Nicobars. It occurs mainly along the banks of streams and on the sides of moist ravines, springing up on landslips and other places where the soil has been exposed, always on well-drained ground. It is essentially a tree of moist warm climates. In its natural habitat the absolute maximum shade temperature varies from 98° to 110° F., the absolute minimum from 36° to 60° F., and the normal rainfall from 50 to 200 in.

Leaf-shedding, flowering, and fruiting. The tree is leafless for a time in the hot season. The clusters of large showy white flowers appear at the ends of the long spreading branches in February–March, weighing them down at the ends. The capsules ripen in the end of April or during May. The seeds (Fig. 228, *a*) are minute, averaging 0·05 in. long, tapering at each end to a point, and very light. Tests at Dehra Dun showed that the seed retains its vitality fairly well for a year. The tree flowers and fruits at an early age (six years in the case of a tree planted at Dehra Dun).

Germination (Fig. 228, *b–d*). Epigeous. The testa splits at one end and the radicle emerges; the hypocotyl elongates, carrying the testa above ground, and the latter falls with the expansion of the cotyledons.

The seedling (Fig. 228).

Roots: primary root at first minute, resembling a fine thread, with a mass of woolly hairs round upper part; by end of first season from two to several inches long, moderately thick, with long branching fibrous lateral roots, chiefly from upper part of main root. *Hypocotyl* distinct, at first less than 0·1 in. long, very fine, white or green, afterwards elongating to 0·2–0·3 in., becoming thicker, often dark red. *Cotyledons* at first less than 0·05 in. long, after-

[1] Report on the Exploration of the Forests in the South Andaman and other Islands, 1906, para. 23.

[2] Draft Working Plan for the North Andaman, 1906.

wards enlarging to 0·15–0·2 in. by 0·1 in., ovate, apex rounded, base obtuse or sub-cordate, entire, delicate, green, later often turning dark red. *Stem* erect, quadrangular, the corners winged by the decurrent leaf-bases, glabrous, green with a pink tinge in first season; internodes in first season 0·1–0·5 in. long. *Leaves* simple, alternate on main stem, opposite on side branches, sub-sessile or with petioles up to 0·2 in. long, exstipulate, first two or three leaves often small and abortive. Normal leaves 1–3 in. by 0·3–0·9 in. in first season, up to 8 by 2 in. in second season, oblong lanceolate, acute or acuminate, base elongated and decurrent down petiole and stem, decurrent wings expanding abruptly on joining stem, entire, glabrous, dark green with petiole and decurrent wings often pink.

After germination the young seedlings are extremely minute, almost resembling green powder on the surface of the ground; they are smaller even than those of *Adina cordifolia* or *Stephegyne parvifolia*. The growth during the first season is slow, a height of only 1 or 2 in. being attained by the end of the year. During the second year the growth is more rapid, a height of 2 ft. or more being attained; thereafter the growth is very rapid. Seedlings raised at Dehra Dun proved to be very sensitive to drought and frost; the former is seldom and the latter never experienced within its habitat. The seedlings are somewhat subject to the attacks of insects, and in the forest young plants are readily eaten by deer and cattle. Young saplings develop characteristic long horizontally spreading branches at an early age.

Natural reproduction. Natural seedlings spring up on newly exposed ground such as landslips and river-banks, and appear to require for their development an abundance of light and absence of drip from overhanging trees. Complete drainage and loose but moist soil also appear to be necessary. Natural reproduction comes up readily on banks of silt in the beds of rivers. Mr. Gamble[1] describes the profusion with which natural seedlings come up on the sites of old charcoal kilns in the Darjeeling *tarai*. The nearest seed-bearers were at least half a mile distant, and the seed must have been carried by wind. The sites of these charcoal kilns evidently offered ideal conditions for the germination of the seed and the development of the seedlings, which did not appear elsewhere in the neighbourhood, even on recently hoed ground.

Experiments at Dehra Dun showed that if seed is scattered soon after ripening over fine earth or powdered charcoal in the open it is washed into heaps by the early monsoon showers, and the minute seedlings appear in groups, but are washed away in quantities during the rains. Only where the drainage is perfect and the young plants grow vigorously enough to obtain hold of the ground before being washed away, is it possible for any seedlings to survive the first season. In the case of charcoal-covered ground it is probable that the exceptional vigour induced by the porosity of the germinating bed is the main cause of the survival of the young seedlings.

Artificial reproduction. Direct sowings on bare hoed ground have been carried out frequently in Bengal, and landslips are occasionally sown up with success. On the whole, however, sowings have proved a failure owing chiefly to the liability of the young plants to be washed away during the first season.

[1] Ind. Forester, iv (1878–9), p. 245.

FIG. 229. *Duabanga sonneratioides.*

FIG. 230. *Duabanga sonneratioides*, crop 6 years old, Darjeeling hills.

In the Mongpoo plantations of the Cinchona Department, in the Darjeeling hills, the seed is sown about the end of May or beginning of June in well-raised seed-beds of porous soil which have been very little manured, and the beds are sheltered by sloping double bamboo mats about 3 ft. above the ground. The seedlings are pricked out once and are not planted out until early in the rains of the following year, when they are about 1 ft. high.

Experiments at Dehra Dun showed that it is impossible to raise seedlings in open seed-beds, as the minute seedlings are washed away or beaten down and destroyed by heavy rain. The best results were attained by mixing the seeds with fine earth and scattering the mixture on very fine porous soil or on powdered charcoal in May or early June in boxes kept under cover or in well-raised seed-beds protected from rain by screens. Great care is necessary to water the beds or boxes with a very fine spray. The seedlings may be pricked out when about 1–2 in. high, and transplanted at the beginning of the next rainy season. Little difficulty was experienced in transplanting the seedlings provided the roots were kept enclosed in balls of earth. Basket planting would probably prove successful, the seedlings being transferred to baskets towards the end of the first rainy season.

Direct sowings on raised mounds under bamboo mats have given some success in the Tista forest division of Bengal. Mounds of loose soil 3 ft. by 3 ft. at the base and 6 in. high are sown with a pinch of seed and covered with bamboo mats 2 ft. by 2 ft. in size raised 1 ft. above the mounds. The mats are removed as soon as the seedlings are well established, that is, about the end of the rainy season. Superfluous plants are removed and used to fill up gaps.

In plantations protection from deer and cattle is necessary for the first few years.

Rate of growth. After the first year or two the growth is rapid, an average height increment of 5 ft. a year or more being not unusual. A sapling at Dehra Dun attained a height of 9 ft. 2 in. and a girth of $6\frac{1}{4}$ in. at 4 ft. from ground-level by the end of the fourth season, including a height-growth of only about $1\frac{1}{2}$ in. during the first season; this, in a locality far outside its natural habitat, and subject to more severe cold than it is ordinarily accustomed to, is very fair growth.

Measurements carried out by Mr. E. Marsden in 1917 in three sample plots in the Darjeeling hills gave the following results:

Duabanga sonneratioides: measurements in sample plots, Darjeeling hills.

	After thinning.						Yield from thinning in 1917.				
				Volume per acre, solid.				Volume per acre, solid.			
Age.	Number of stems per acre.	Mean girth.	Mean height.	Timber over 24 in. girth.	Small-wood.	Total.	Number of stems per acre.	Timber over 24 in. girth.	Small-wood.	Total.	Locality.
years.		ft. in.	ft.	cub. ft.	cub. ft.	cub. ft.		cub. ft.	cub. ft.	cub. ft.	
3	328	0 11·6	34	—	310	310	317	—	123	123	Below Lopchu.
6	131	2 2·0	50	364	559	923	86	—	316	316	Near Birick.
10	110	3 3·7	78	2,308	408	2,716	99	—	575	575	Sumbong.

The second of these plots is shown in Fig. 230. These figures show a very rapid rate of growth and a high yield. Trees measured in 1915 in a plantation in the Jalpaiguri district had attained a height of 18 ft. in five years.

The rate of growth as deduced from measurements in two unthinned sample plots in the Darjeeling division was as follows :[1]

Duabanga sonneratioides : girth increment in unthinned sample plots, Darjeeling division.

Age.	Mean girth.	Age.	Mean girth.
years.	ft. in.	years.	ft. in.
10	1 10¼	40	5 2¾
20	3 2	50	6 4
30	4 2½	60	7 4½

The growth here is considerably slower than that shown in the first statement : this is possibly due to the fact that no thinnings were carried out.

Ring-countings in respect of 25 trees in the Tista valley gave an average of 3·1 rings per inch of radius, representing a mean annual girth increment of 2·026 in.[2]

Gamble's specimens averaged 5 rings per inch of radius (mean annual girth increment 1·26 in.), while one specimen showed 2 rings per inch (mean annual girth increment 3·14 in.).

3. SONNERATIA, Linn. f.

This genus comprises trees with opposite entire thick leaves, growing in the mangrove swamps of littoral regions (see under 'Rhizophoraceae'). There are four Indian species, of which two, *S. acida*, Linn. f., and *S. apetala*, Ham., are fairly widely distributed along the coasts and two, *S. alba*, Smith, and *S. Griffithii*, Kurz, are far more local.

Species 1. *S. apetala*, Ham.; 2. *S. acida*, Linn. f.; 3. *S. Griffithii*, Kurz; 4. *S. alba*, Smith.

1. **Sonneratia apetala**, Ham. Vern. *Keora*, Beng.; *Kandal*, Mar.; *Kylanki*, Tel.; *Marama*, Tam.; *Kanbala*, Burm.

A small to moderate-sized evergreen tree with slender drooping branches and light glaucous-green foliage. Bark black, smooth, with horizontal oval lenticels. The tree produces thin upright rather sharp pneumatophores from its superficial roots. It coppices vigorously. Wood moderately hard, used for planking, furniture, knees of boats, and fuel.

Distribution and habitat. Tidal forests of the coasts of India and Burma. This is one of the chief constituents of the mangrove formation, growing gregariously and springing up in more or less pure patches, usually on new alluvial land thrown up in the form of islands or of flats in the bends of tidal rivers and estuaries. It is a common tree in the Sundarbans, appearing on newly formed land and gradually dying out on the higher ground, where it tends to be replaced by *Heritiera Fomes* and other species.

Flowering and fruiting. The whitish flowers appear from April to June. Ripe fruits have been received from the Sundarbans in September.

[1] Statistics compiled in the Silviculturist's Office, 1916–17, Ind. For. Rec., vol. vi, pt. v.
[2] Working Plan for the Darjeeling Forests, J. W. A. Grieve, 1912.

They are globose, about 0·7–0·8 in. in diameter, fleshy, indehiscent, containing several angular irregularly-shaped seeds about 0·3 in. long, with a rather hard testa. The fruits are buoyant, and are distributed by water; they are also said to be eaten by birds. After falling they soon rot and disintegrate, the seed being scattered.

Germination. Epigeous. The testa splits at one end and the radicle emerges. The hypocotyl arches and the testa is carried above ground, falling with the expansion of the cotyledons.

Rate of growth. Mr. Trafford[1] notes that this tree grows more rapidly than any other in the Sundarbans; he estimates the mean annual girth increment at 1·2 in.

2. **Sonneratia acida,** Linn. f. Vern. *Ora, orcha*, Beng.; *Tiwar*, Mar.; *Thirala*, Mal.; *Tabu, tamu*, Burm.

A small evergreen tree with dull green foliage and black shining lenticellate bark. It produces pneumatophores in the shape of asparagus-like rootlets emerging from the mud. This is another common species of the mangrove swamps, with an even wider distribution than *S. apetala*.

3. **Sonneratia Griffithii,** Kurz.

A species of the Burma coast, strongly resembling *S. acida*.

4. **Sonneratia alba,** Smith.

A shrub or small tree of the mangrove swamps of the Andamans, Mergui, and the Konkan (Brandis).

4. WOODFORDIA, Salisb.

Woodfordia floribunda, Salisb. Vern. *Dhaula, dhau, dáwi*, Hind.; *Dhaiti*, Mar.; *Jaji*, Tel.; *Yetkyi, pattagyè, panlè*, Burm.

A large shrub with more or less fluted stem and long spreading branches, widely distributed throughout India and the drier parts of Burma, ascending to 5,000 ft. in the Himalaya; also in Africa, Arabia, China and elsewhere, and in Ceylon (rare).

This is a common gregarious shrub which springs up on landslips, abandoned cultivation, and other open places, killing out grass and acting as a useful soil-improver and a most efficient nurse to tree species, including sal, which come up freely under its protective cover. For clothing landslips it is invaluable. It is not eaten by cattle, and is frost-hardy, and thus appears often in extensive pure masses on open ground subject to grazing. In tracts where shifting cultivation has been practised the presence of old bushes of *Woodfordia* gradually dying out under the shade of poles of tree species usually indicates the site of a former cultivated clearing in which the shrub has appeared and the tree species have grown up through it, eventually suppressing it.

The bright red flowers, which appear from January to April in axillary cymes along the spreading branches, make the plant a conspicuous sight. The capsules ripen from April to June and shed the minute seeds, which require open well-drained ground for germination. Mr. Haines notes that it scatters its seeds slowly for several weeks, and only that seed germinates

[1] Working Plan for the Sundarbans, 1912.

and survives which is lucky enough to fall just before a several days' period of continuous wet weather.[1]

The most successful way in which to grow the plant artificially is to sow the seeds in broken bricks ; on ordinary seed-beds it is very difficult to obtain germination and to raise seedlings. The plant coppices well ; coppice-shoots five years old in the Gorakhpur district, United Provinces, averaged 10 ft. 3 in. in height.

5. PUNICA, Linn.

Punica Granatum, Linn. Pomegranate. Vern. *Anar*, Hind. ; *Dharu, daruna*, Pb.

A deciduous shrub or small tree, indigenous in Persia and Afghanistan ; wild and probably indigenous in Hazara, where it is very common and often gregarious on dry rocky ground on the limestone of the outer hill ranges at 3,000–5,000 ft., often associated with *Olea cuspidata* ; also found in the Kagan valley up to 6,000 ft. on dry hill-sides. It is widely cultivated for the sake of its fruit, and is frequently found as an escape from cultivation, particularly in the Himalaya, where it ascends to 7,000 ft. and where it sometimes forms dense crops on the gravel and boulder deposits in the beds of dry ravines and similar places. It is cultivated from seed or from cuttings. In the Himalaya it flowers chiefly from April to July, and the fruits ripen from July to October.

ORDER XXX. SAMYDACEAE

Genera 1. Casearia, Jacq. ; 2. Homalium, Jacq.

1. CASEARIA, Jacq.

Species 1. *C. tomentosa*, Roxb. ; 2. *C. glomerata*, Roxb.

1. **Casearia tomentosa**, Roxb. Vern. *Chilla, bheri*, Hind. ; *Modi*, Mar.

A small deciduous tree with spreading branches, tomentose leaves, and small greenish flowers clustered in the axils of the leaves. The wood is of little use, but the tree is common in the sub-Himalayan tract and the Indian Peninsula in deciduous forests, open scrub jungles, and waste lands. It often owes its abundance to its immunity from damage by grazing. It is very drought-hardy, as was shown in the abnormal drought of 1907 and 1908 in Oudh. It suffered much in the severe frost of 1905 in northern India, but apparently has good powers of recovery, since it is frequent in grassy blanks subject to annual frosts. The tree coppices well. The rate of growth in high forest is slow, sample plots in sal forest in the United Provinces showing mean annual girth increments of 0·09, 0·19, 0·22, and 0·34 in. Coppice-shoots grow more rapidly. Measurements made in 1911 in a coppice coupe one year old in the Tikri forest, Gonda, United Provinces, showed an average height of 4·5 ft. as against 4·7 ft. for sal. Measurements made in 1910 by Mr. McCrie in coppice coupes in Gorakhpur, United Provinces, showed the following results for *Casearia tomentosa* and sal respectively :

[1] Inspection note, Palamau, 1915.

Casearia tomentosa : coppice measurements, Gorakhpur, United Provinces.

	Mean girth.		Mean height.	
Age.	*Casearia.*	Sal.	*Casearia.*	Sal.
years.	in.	in.	ft.	ft.
2	—	—	3·5	3·0
4	1·7	2·0	6·0	7·0
6	2·4	2·9	8·0	10·3
8	3·0	3·8	9·5	13·0
10	3·5	4·8	11·0	15·3
12	4·0	5·8	12·5	17·5
14	4·5	6·7	14·0	19·2
16	5·0	7·5	15·0	20·9

The following measurements were recorded in 1886 by Mr. A. F. Broun in coppice coupes at Bullawala, Dehra Dun :

Casearia tomentosa : coppice measurements, Bullawala, Dehra Dun.

	Mean girth.		Mean height.	
Age.	*Casearia.*	Sal.	*Casearia.*	Sal.
years.	in.	in.	ft.	ft.
8	5·2	8·3	12·5	6·2
8	6·0	..	22·0	..
9	7·2	8·6	15·0	16·0
10	7·6	5·9	14·0	11·9

2. **Casearia glomerata,** Roxb. Syn. *C. graveolens*, Dalz. Vern. *Chilla, nara*, Hind. ; *Giridi*, Uriya ; *Bokhada*, Mar. ; *Barkholi*, Nep.

A small to moderate-sized deciduous tree, sometimes a mere shrub, with long spreading branches and leaves which turn a deep coppery red in the cold season. Brandis unites *C. glomerata*, Roxb., and *C. graveolens*, Dalz. Gamble (*Man. Ind. Timbers*) describes the former as a large evergreen tree of the eastern Himalaya, Khasi hills, Sylhet, and hills of Upper Burma. Manson,[1] describing the eastern Himalayan tree, notes that it is often found in second growth forest, perhaps most commonly on warm sunny aspects ; seedlings are plentiful and do well with plenty of light while thriving also under cover, and the tree is a capital nurse for restocking blanks.

The tree is common in mixed forests throughout the greater part of India and in Burma, where it is frequent in the lower mixed forests. The wood is little used.

2. HOMALIUM, Jacq.

Homalium tomentosum, Benth. Vern. *Myaukchaw*, Burm.

A large deciduous tree with thin very smooth whitish bark, found in deciduous forests throughout Burma except in the drier parts of the dry zone. Also in Chittagong and the Northern Circars (Gamble). This is one of the most characteristic trees of the mixed deciduous forests of Burma, its smooth clean white bole rendering it very conspicuous. It attains large dimensions ; Fig. 231 shows a tree 12 ft. in girth and 120 ft. in height. It is abundant in the upper mixed forests with teak, *Xylia dolabriformis*, and their associates (see Fig. 232). It is also common in the better drained portions of the lower mixed forests, but not in areas which are water-logged for part of the year. Generally speaking, its presence appears to be an indication of good drainage.

[1] Working Plan for the Darjeeling Forests, 1893.

It seeds freely, and natural seedlings often spring up in great abundance, standing moderate shade and often forming dense pure thickets : in some of the teak plantations of Burma natural reproduction springs up freely and forms a lower story to the teak. The factors influencing natural reproduction have not been studied in detail. Seedlings raised at Dehra Dun succumbed to frost, which, however, is not met with in their natural habitat. The tree coppices well ; an average of 3 shoots per stool was recorded in coppice measurements in the Rangoon plains forests. The wood is tough and elastic, but is apt to develop small cracks in seasoning. It is an excellent fuel. The rings are distinct on a smooth cross-section. A specimen from Burma showed 9 rings per inch of radius, giving a mean annual girth increment of 0·7 in.

ORDER XXXI. DATISCACEAE

TETRAMELES, R. Br.

Tetrameles nudiflora, R. Br. Vern. *Jermala, bondale,* Kan. ; *Ugad,* Mar. ; *Chini,* Tam., Mal. ; *Thitpôk,* Burm. ; *Baing,* U. Burm.

A lofty deciduous tree with a long clean bole and immense plank buttresses at the base. Bark greyish white, fairly smooth. This tree is a conspicuous one in moist tropical and evergreen forests in the eastern sub-Himalayan tract and outer hills, Western Ghats and Nilgiris, and in Burma, towering above the evergreen vegetation. Gamble records a tree measured by him in the Buxa forests, Bengal, 154 ft. high and 15 ft. in girth. It sheds its leaves about January, and the new leaves do not appear until late in the hot season or early in the rains. The yellowish green flowers, which appear in February–March when the tree is leafless, are much sought after by bees, which often build their hives in this tree : the capsules ripen in April–May, and the small seeds are carried to a distance by the wind. The rate of growth is rapid, but no detailed records are available. The wood is whitish, soft, rather coarse, and not durable ; in southern India it is used for dug-out canoes, after treatment with fish oil to increase its durability : it is also used for rough packing-cases

ORDER XXXII. CACTACEAE

OPUNTIA, Mill. Prickly pear.

The name ' prickly pear ' has been given to certain species of *Opuntia* introduced from South America. The commonest species naturalized in India is *O. Dillenii,* Haw., with flat succulent jointed branches, long sharp spines, and tufts of bristles ; the flowers are bright yellow tinged with red. A red-flowered species common in the neighbourhood of Madras is said to be *O. spinosissima,* Mill.

Prickly pear was introduced into India, it is believed, less than a century ago, but it has spread with such rapidity in the drier parts of the country, particularly in the Deccan and southern India, that it is now one of the most noxious weeds with which the forest officer has to contend. Provided it is kept in check it is an extremely good hedge plant, pieces of the stem and branches stuck in the ground quickly taking root, spreading and forming an

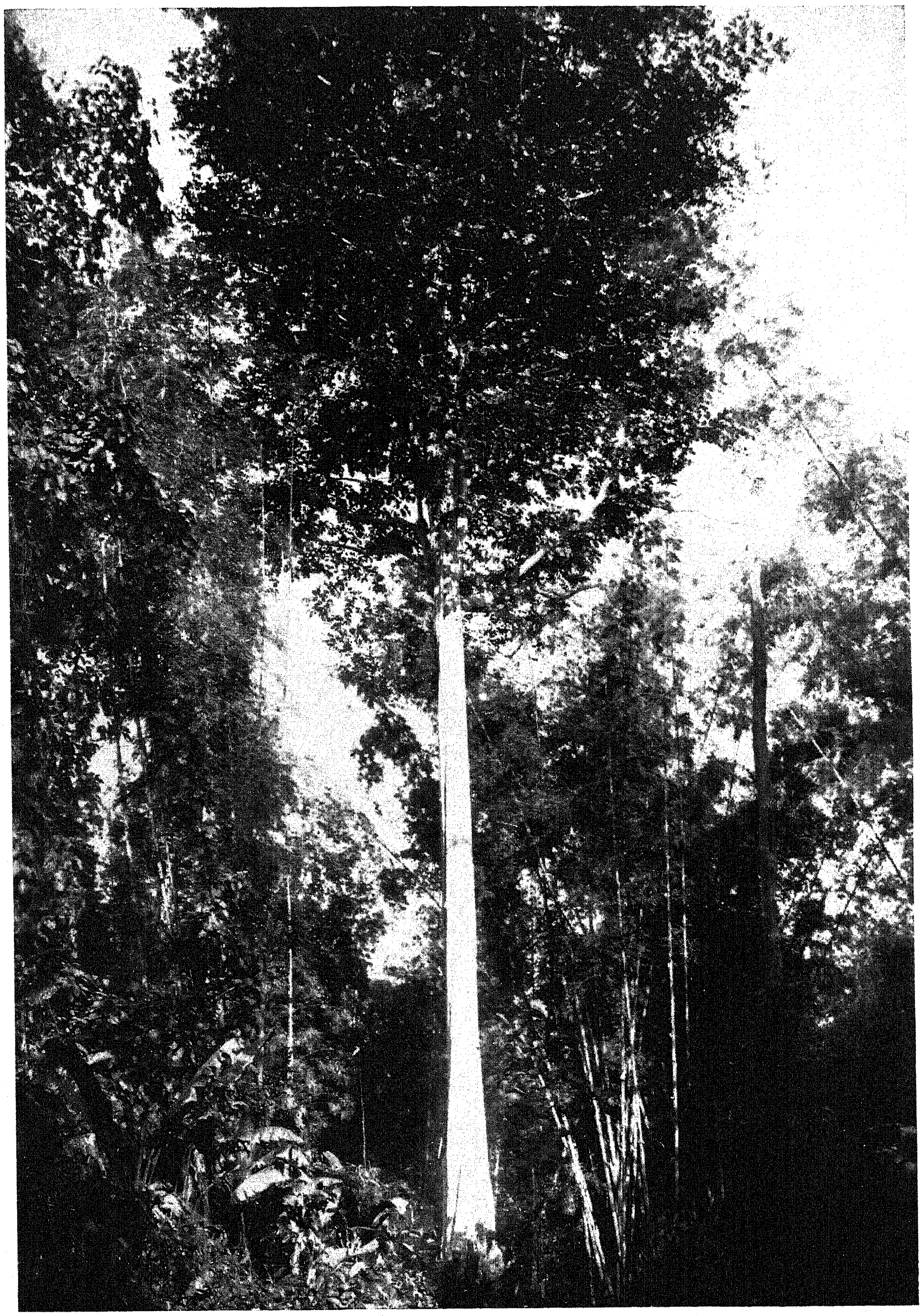

FIG. 231. *Homalium tomentosum*, girth 12 ft., height 120 ft., Minhla reserve, Tharrawaddy, Burma ; the bamboo is *Bambusa polymorpha*.

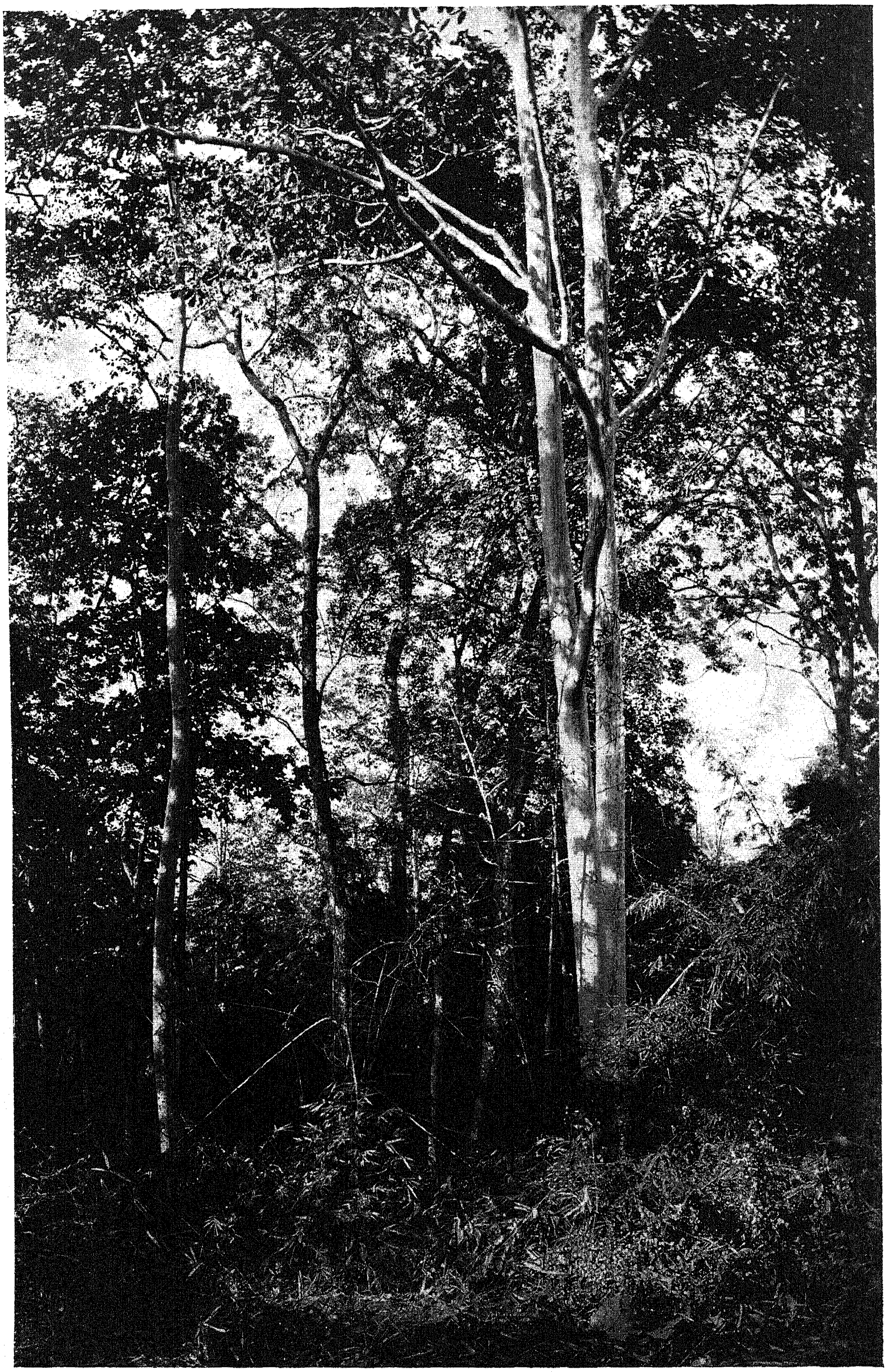

FIG. 232. *Homalium tomentosum* (two white smooth-barked trees, the right-hand one forked) in upper mixed forest, Prome, Burma.

impenetrable and formidable hedge. The fruits are eaten by man, animals, and birds, and the seeds are spread by their agency. The plant thrives on dry barren ground and is amply protected by its spines, and thus it spreads unchecked over waste and forest lands even where there is heavy grazing. To some extent it serves a useful purpose in grazed areas, in affording protection to seedlings of forest trees, which are able to establish themselves amid the clumps of prickly pear. But any good effect the plant may have in this respect is far outweighed by the harm it does in monopolizing large areas to the exclusion of forest growth and fodder grass.

Various efforts have been made to eradicate prickly pear over given areas, particularly in Madras, but the process has proved a costly one. Mere cutting or uprooting is of little avail, since the cut pieces, if left on the ground, merely take root and produce new masses of prickly pear. Burying the cut pieces in deep pits has been tried, but even with a covering of earth 1 ft. thick new plants made their way up and the surface of each pit became a dense mass of prickly pear. Stacking the cut pieces on a layer of brushwood and burning them proved more successful, the stacks being left to dry for a few months and then burnt: a few young plants subsequently came up, but they were dug up without difficulty. Mr. A. Lodge has tried poisoning the prickly pear by cutting it into pieces and watering them with a weak solution of arseniate of soda; the results were quite successful, the pieces turning black and shrivelling up, but the operation was expensive, and the use of a deadly poison necessitated careful supervision.

It is doubtful if the eradication of prickly pear over extensive areas will be feasible unless some means can be discovered of recouping the cost by providing for its remunerative utilization. When deprived of its spines it is utilizable as fodder for cattle, though the latter appear to take to it only by degrees. An interesting experiment in burning off the spines and feeding cattle with chopped-up pieces of prickly pear, to which 6 per cent. by weight of cotton seed was added, is described by Messrs. E. W. Horn and S. G. Mutkekar in the *Agricultural Journal of India*, vol. ix, pt. ii (April 1914), p. 190. The experiment in question proved decidedly successful, the animals gaining appreciably in weight and condition. A method of burning off the spines with vaporized petrol is described in the *Indian Forester*, vol. xlii (1916), p. 379 (quoting from the *Pioneer*). Other possible uses for the prickly pear which have been suggested are the manufacture of alcohol or of paper pulp.

ORDER XXXIII. RUBIACEAE

A large and important order, furnishing not only useful timber trees but also trees and shrubs yielding drugs, dyes, and edible products, e. g. *Cinchona*, *Coffea*, *Morinda*, and *Rubia*. Most of the important timber trees (*Anthocephalus*, *Adina*, *Nauclea*, and *Stephegyne*) are characterized by very small light seeds which for successful germination require bare ground devoid of weed-growth, while the minute seedlings are liable to perish in quantity through being washed away by rain; their reproduction is therefore dependent on somewhat special conditions.

Genera 1. ANTHOCEPHALUS, A. Rich.; 2. ADINA, Salisb.; 3. STEPHEGYNE,

Korth.; 4. NAUCLEA, Linn.; 5. HYMENODICTYON, Wall.; 6. WENDLANDIA, Bartl.; 7. GARDENIA, Linn.; 8. RANDIA, Linn.

1. ANTHOCEPHALUS, A. Rich.

Anthocephalus Cadamba, Miq. Syn. *A. indicus*, A. Rich.; *Nauclea Cadamba*, Roxb.; *Sarcocephalus Cadamba*, Kurz. Vern. *Kadam*, Hind.; *Roghu*, Ass.; *Kadwal*, Kan.; *Kadambe*, Tel.; *Vellei kadambu*, Tam.; *Mau*, Burm.

A large deciduous (or sometimes evergreen ?) tree with spreading branches and rather large shining leaves with prominent veins; the leaves are much larger in young saplings and coppice-shoots than in older trees. Bark grey, smooth in young trees, becoming darker and longitudinally fissured in older trees, exfoliating in small rectangular plates, yellowish brown inside. Wood yellowish white, soft, an excellent tea-box wood, and also used for planking, dug-out canoes, &c.; has been highly recommended for match manufacture. This tree deserves more attention as a useful fast-growing soft-wooded species.

DISTRIBUTION AND HABITAT. The sub-Himalayan tract from Nepal eastwards, Bengal, Assam, Chota Nagpur (valleys in Singhbhum, Haines), Burma, Northern Circars, and the west coast from North Kanara southwards to Travancore, but Talbot does not consider it indigenous in the Bombay Presidency; also in Ceylon. It is cultivated in many parts of India. It is a tree of moist warm regions, frequenting moist types of deciduous and evergreen forests, and often occurring on alluvial ground along rivers and also on swampy ground. It prefers deep well-drained moist alluvium; on stiff badly-drained ground the growth is poor. In its natural habitat the absolute maximum shade temperature varies from 96° to 110° F., the absolute minimum from 38° to 60° F., and the normal rainfall from 60 to 200 in. or more.

LEAF-SHEDDING, FLOWERING, AND FRUITING. The leaves fall in the hot season, the tree becoming leafless or nearly so. The small orange-coloured flowers, in globose heads 1·5 to 2 in. in diameter, appear chiefly from May to July. The fruits ripen and fall in January–February (Bengal Duars); the pseudocarp is a globose orange fleshy mass of closely packed capsules each containing a number of minute seeds (Fig. 233, *a*), the whole 1·5–2·5 in. in diameter. The fruits are eaten by man and also by cattle, fruit-bats, and other animals, and by birds, the seeds being distributed by their agency. The tree flowers and fruits at an early age (five years in the case of a tree at Dehra Dun).

GERMINATION (Fig. 233, *b–e*). Epigeous. The radicle emerges and the hypocotyl elongates, carrying above ground the cotyledons enclosed in the testa, which usually remains adhering to one cotyledon for some time before falling to the ground.

THE SEEDLING (Fig. 233).

Roots: primary root at first thin, later becoming long and thick, terete, tapering: lateral roots numerous, long, distributed down main root but chiefly in its upper part. *Hypocotyl* distinct from root, 0·1–0·3 in. long, terete or slightly compressed, glabrous in young stages. *Cotyledons* sessile, under 0·05 in. long, ovate, acute, entire. *Stem* erect, slightly compressed, sometimes grooved, finely tomentose; internodes 0·3–1·2 in. long. *Leaves* simple, opposite,

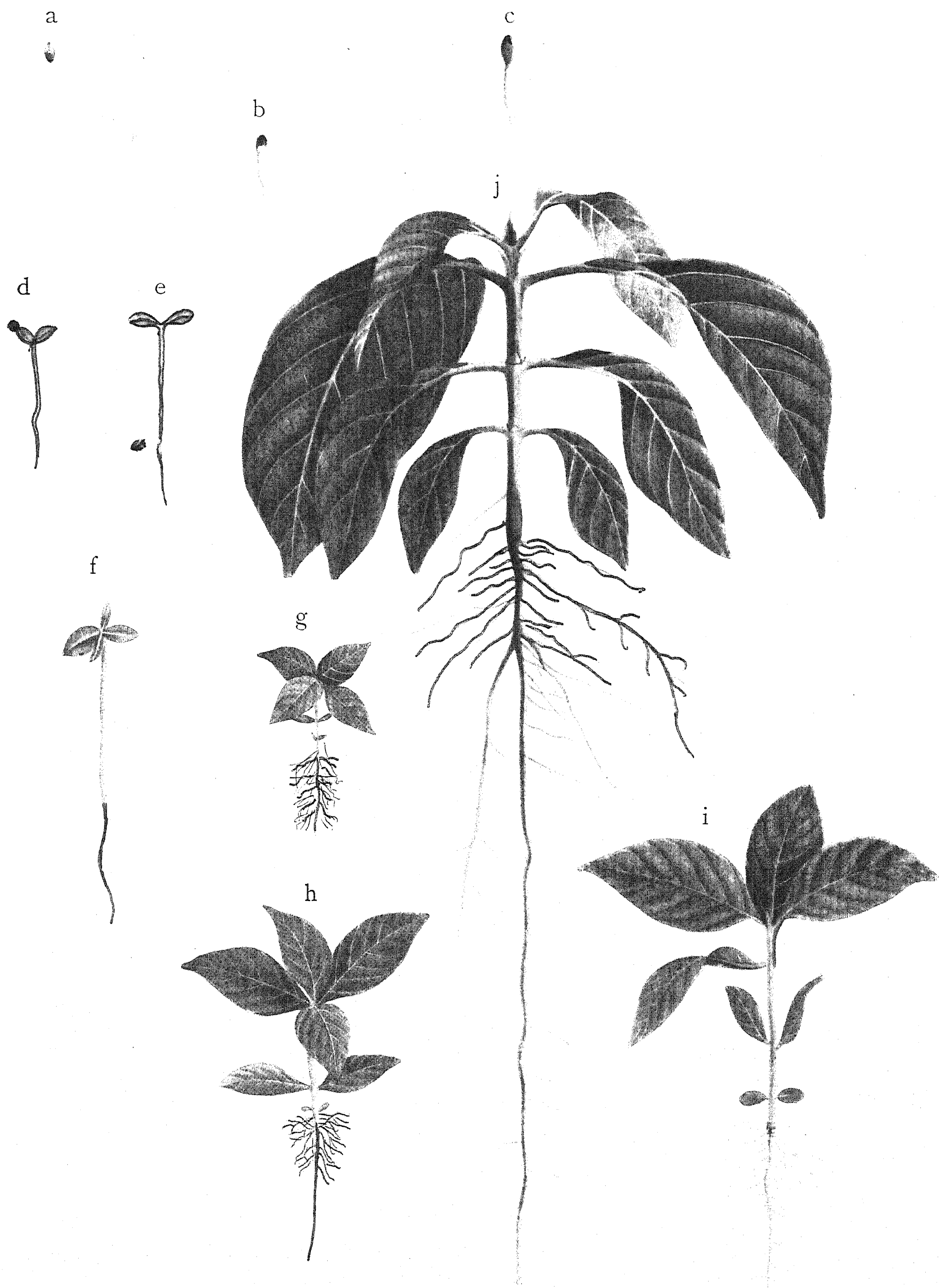

FIG. 233. *Anthocephalus Cadamba*—SEEDLING

a—Seed × $\frac{1}{1}$ b-e—Germination stages × $\frac{1}{1}$ f-j—Development of seedling to end of first season (f × $\frac{1}{1}$, g-j × $\frac{1}{2}$)

first one or two pairs often abnormally small, 0·1–0·4 in. long. Stipules 0·1–0·4 in. long, triangular, acuminate, fimbriate, pubescent, enclosing the terminal bud. Petiole 0·3–0·8 in. long, flattened above, pubescent. Lamina 1–4·5 in. by 0·4–2·5 in., elliptical ovate or obovate, apex acute or acuminate, base tapering, entire, glabrous or glabrescent above, pubescent beneath ; venation arcuate, lateral veins 5–8 pairs, veins of younger leaves often pink.

The young seedlings for the first few weeks after germination are minute, and growth during the first season is comparatively slow, a height of 2–6 in. being ordinarily attained by the end of the season. From the second season onwards, however, the growth is very rapid. Seedlings raised at Dehra Dun reached a height of 6–8 ft. by the end of the second season, and under climatic conditions more suited to this species the growth is faster.

In their younger stages the seedlings are very sensitive to drought and are also liable to damp off with an excess of moisture in the soil. They are very sensitive to frost, which, however, is unknown in the natural habitat of the tree. Seedlings are much subject to damage by insects, especially during the first few weeks.

Silvicultural characters. Although young plants will stand a little shade, and require protection from the heat of the sun in their earlier stages, the tree may be regarded as a light-demander ; saplings grown under shade become spindly in their efforts to reach the light. The tree coppices vigorously. It is sensitive to frost, which, however, does not occur in its natural habitat. Young saplings are very subject to damage from browsing by cattle and deer, and in grazed areas are prevented from making headway.

Natural reproduction. As already noted, the fruits are readily eaten by cattle and other animals and by birds, and the seeds are spread by their agency. Fruits which fall to the ground and remain uneaten soon disintegrate or are partly consumed by white ants, and with the early showers preceding the monsoon the seeds are washed into heaps along with silt, germinating often in dense masses at the commencement of the rainy season : large numbers of the small seedlings are washed away and destroyed, and it is only where they obtain a secure lodgement until the end of the first rainy season that they have a chance of surviving. Cattle are rather important agents in securing natural reproduction. Seedlings often come up in considerable quantities in grazed areas or in places where cattle are herded together : the young plants are browsed down regularly, but if cattle are kept out for a time the saplings shoot up and establish themselves. In the Bengal Duars excellent natural reproduction may be found coming up in areas previously grazed, but recently closed to grazing (see Fig. 234). In the same locality saplings may often be found springing up in grazed areas under the protection of thickets of *Zizyphus Jujuba*, *Acacia Catechu*, and other thorny species. Reproduction also has a tendency to spring up on newly exposed ground, for example on the sides of new road embankments. Natural seedlings sometimes appear in great abundance ; thus Mr. S. E. Peal, quoted by Gamble, says he once estimated that he weeded out 450,000 seedlings on 25 acres of clearance.

Artificial reproduction. The artificial raising of this species from seed is not difficult, but requires great care owing to the small size of the seeds and the seedlings and their liability to be washed away, and to the sensitiveness of the seedlings to drought on the one hand and excessive moisture on the

other. Direct sowings cannot be relied on. Young plants can be raised successfully by broadcasting on well-pulverized fine earth either in well-raised nursery-beds or in boxes; it is necessary that the beds or boxes should be sheltered from the sun and rain, watering being carried out with a very fine spray frequently but sparingly. Sowing may be done from March to May, and the plants should be pricked out in beds during the first season, when about 2 in. high. The larger plants may be transplanted during the first rainy season, but the remainder should be kept for a year in the beds and transplanted early in the following rainy season.

RATE OF GROWTH. During its earlier years the growth is very rapid. Trees planted in 1911 in an avenue at Rajabhatkhawa in the Buxa Duars reached a girth of over 2 ft. and a height of 30 ft. in four years. Mr. S. E. Peal[1] says that the growth is remarkably rapid for the first six or eight years, averaging 10 ft. in height per annum; the growth becomes slower up to twenty years and then becomes very slow. He records measurements of trees sixteen years old which had reached a girth of 5 ft. 5 in. at 6 ft. and 3 ft. 8 in. at 30 ft. from ground-level; for tea-box planking he considers it most profitable to fell at twelve years of age. Sir George Hart notes a case of rapid growth on a low-lying alluvial flat along the Saing river in Toungoo, Burma. Here an attempt was made to establish a teak plantation in 1895. The teak failed, but *Anthocephalus Cadamba* came in naturally. In January 1918, when they could not have been more than twenty-two years old, some of the trees were measured and found to have girths of 7 ft. 6 in., 6 ft. 5 in., 5 ft. 7 in. (twice), and 5 ft. 6½ in.; the height was estimated to be not less than 100 ft., and was probably more nearly 120 ft.

2. ADINA, Salisb.

Adina cordifolia, Hook. f. Syn. *Nauclea cordifolia,* Willd. Vern. *Haldu,* Hind.; *Heddi,* Mar.; *Yettagal,* Kan.; *Manja kadambu,* Tam. and Mal.; *Hnaw,* Burm.

A large deciduous tree with a large crown and cordate leaves. Under forest conditions the tree produces a long straight clean bole, but it is often buttressed and fluted at the base, the buttresses sometimes being of irregular and fantastic shapes. In more isolated positions it produces a thick bole and massive branches with a large spreading crown (see Fig. 236). Bark grey, exfoliating in patches which leave indentations, pinkish inside. Wood yellow, moderately hard, even grained, used for building, furniture, turnery, bobbins, boxes, &c. The tree attains large dimensions. Mr. A. Rodger records one 17 ft. in girth in the Paungadaw reserve, Ruby Mines district, Upper Burma. Mr. H. R. Blanford in 1917 took measurements of a *Ficus*-bound tree felled in the Katha district, Upper Burma. The tree was hollow, and the breast-height girth over the *Ficus* was 24 ft. 5 in. Other dimensions recorded were: (1) total height 138 ft.; (2) length of bole 61 ft.; (3) height to first branch 48 ft.; (4) girth at height of 32 ft. from ground 14 ft. 2 in., and at height of 56 ft. from ground 13 ft. 2 in.

DISTRIBUTION AND HABITAT. *Adina cordifolia* is found scattered in deciduous forests throughout the greater part of India and Burma; also in

[1] Ind. Forester, x (1884), p. 245 (quoting from Ind. Tea Gazette.).

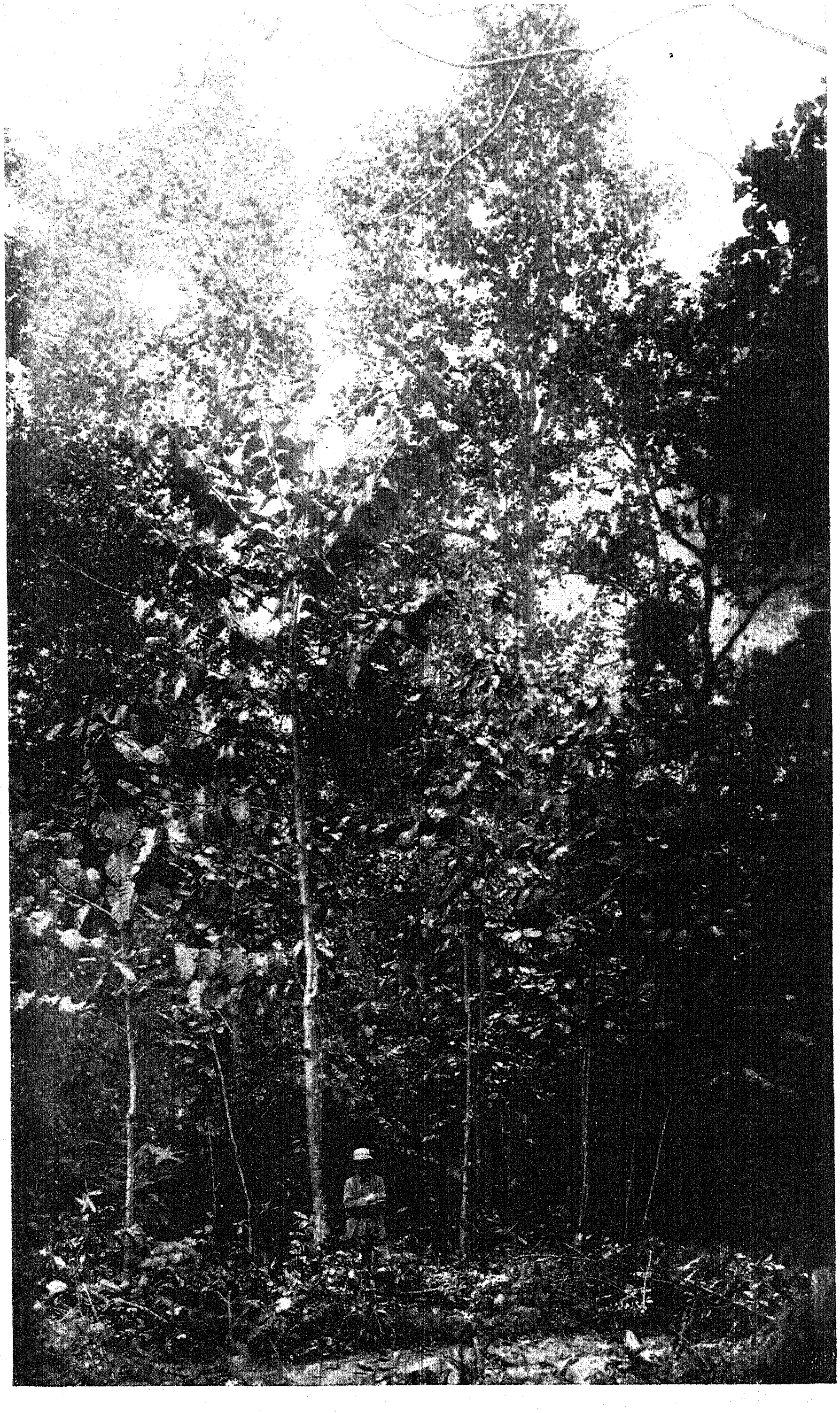

FIG. 234. *Anthocephalus Cadamba*, natural reproduction on an area formerly grazed but free from grazing in recent years, Buxa division, Bengal.

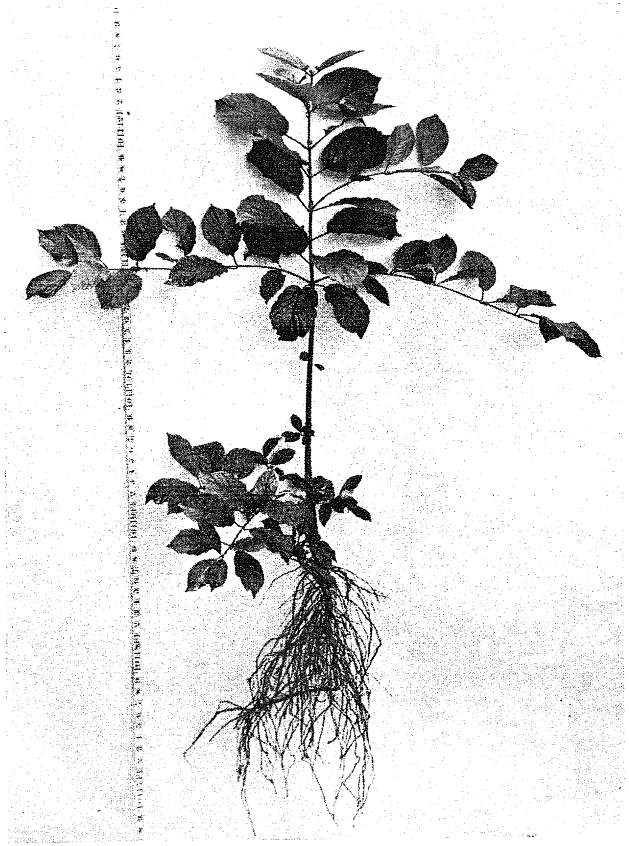

FIG. 235. *Adina cordifolia*, vigorous seedling in third season, taproot broken.

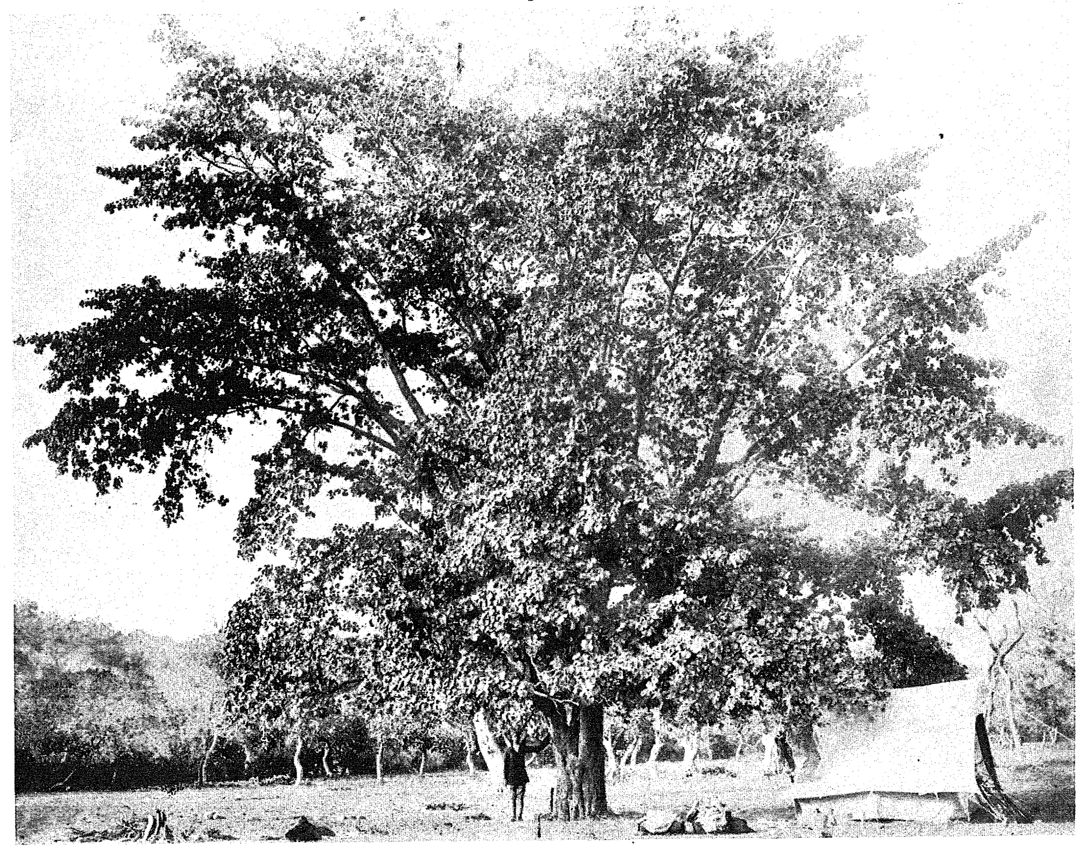

FIG. 236. *Adina cordifolia*, Siwalik hills, United Provinces.

the dry regions of Ceylon. In the sub-Himalayan tract large trees are found along the lower slopes of the outer hills from the Jumna eastwards and on the boulder terraces at the base of these hills, where it is sometimes almost gregarious. It is also a familiar tree in the sal forests of the United Provinces. It is fairly common in mixed deciduous and sal forests in Chota Nagpur, and is scattered throughout the greater part of the Central Provinces and the Indian Peninsula generally. In Burma it is found both in the upper mixed and in the lower mixed deciduous forests.

The tree is found most frequently, and attains its best development, on well-drained ground, for instance along the lower slopes of hills among boulders; it also grows well on alluvial ground provided the drainage is good. Like *Stephegyne parvifolia* it is sometimes met with in the sub-Himalayan tract round the edges of swampy depressions where the soil is stiff and the drainage deficient, but in such places it is always stunted and tends to become stag-headed early.

In its natural habitat the absolute maximum shade temperature varies from 100° to 118° F., the absolute minimum from 30° to 55° F., and the normal rainfall from 35 to 150 in.

LEAF-SHEDDING, FLOWERING, AND FRUITING. The leaves are shed about February and the trees remain leafless until about May–June, when the new foliage appears. The large whitish stipules enclosing the leaf-buds are conspicuous; they fall to the ground when the young leaves appear. The yellow globose flower-heads, about 0·6–1 in. in diameter, appear from June to August. By October the globose fruit-heads are almost fully formed, but are still green and unripe; they do not actually ripen and shed their seeds until from April to June of the following year (northern India). The fruit-head (Fig. 237, *a*) consists of a large number of small two-valved many-seeded capsules. After the capsule-valves and seeds have been shed the remains of the fruit-heads appear like small prickly balls formed of the bristle-like axes of the capsules; these, on their peduncles 1–3 in. long, soon fall to the ground and may be found there in quantity during the rainy season. Sometimes the ripe fruit-head falls before shedding the seeds, which may even germinate within the fallen fruit-head (Fig. 237, *b*).

The seeds (Fig. 237, *c*) are very small and light, 0·06 to 0·12 in. long, brown, with numerous minute longitudinal wrinkles, one end tapering to a point, the other terminating in a pair of pointed appendages. As many as 11,000 seeds weigh 1 gramme, giving over 300,000 to the ounce avoirdupois. Tests carried out at Dehra Dun showed that the seed, if carefully stored, retains its vitality well for at least a year.

GERMINATION (Fig. 237, *d–g*). Epigeous. The minute radicle emerges from the blunt end of the seed, the hypocotyl elongates, arching slightly, and the testa, enclosing the cotyledons, is carried above ground, falling with their expansion.

THE SEEDLING (Fig. 237).

Roots: primary root in first season very fine, white, delicate, with a dense mass of woolly hairs in the upper part which soon disappears; in the second season much thickened, tough, terete, tapering, yellowish brown: lateral roots moderate in number and length, fibrous, distributed down main root,

chief lateral roots thickening considerably in second season. *Hypocotyl* distinct from root, 0·1–0·15 in. long, very fine and delicate, white turning green. *Cotyledons* sub-sessile or very shortly petiolate, up to 0·1 in. long, ovate, acute, base truncate or sub-cordate, entire, foliaceous, delicate, green, glabrous. *Stem* erect, terete or compressed, delicate at first, becoming woody later, tomentose; internodes at first 0·1–0·2 in. long, in second season up to 1 in. long. *Leaves* simple, opposite decussate. Leaves of the first season usually only two pairs: petiole up to 0·05 in. long, lamina 0·1–0·5 in. by 0·08–0·4 in., ovate, acute or obtuse, base obtuse, entire, usually reddish, glabrous, or minutely pubescent beneath. Leaves of second season: stipules 0·2–0·5 in. long, ovate, obovate or elliptical, pale green, terminal pair enclosing terminal bud: petiole up to 0·5 in. long, flattened above, tomentose: lamina up to 3·5 by 2 in., elliptical ovate, acute, base acute or obtuse, more rarely cordate, entire, glabrous above, paler and minutely pubescent beneath, lateral veins 6–9 pairs.

For some little time after germination the seedlings are extremely minute and delicate, and are very liable to be washed away or beaten down by the rain. During the first season their development is slow, many attaining a height of only 1 in. or less, with two or three pairs of leaves, though under favourable conditions the more vigorous individuals may attain a height of 4–6 in. or even more, with seven or eight pairs of leaves. During the second season the growth is more rapid, a height of 1–2 ft. or even more being attained under favourable conditions, though on stiff soil or weed-covered ground the growth is poor; good drainage and a free porous soil are essential conditions for successful development. The taproot remains thin, but attains a fair length, during the first season; during the second season, however, it thickens considerably, attaining in some cases a diameter of as much as ½ in. The seedlings are very sensitive to frost and drought. The leaves turn reddish-brown in the cold season and fall about November to February, the new leaves appearing about March or later (northern India). Fig. 235 shows a vigorous seedling in the third season.

In the forest the seedlings require some practice to recognize, even when two or three years old. Superficially they are not unlike those of *Clerodendron infortunatum*, a plant often occurring in the sal forests where *Adina* is found. The *Adina* seedlings, however, can always be distinguished by the terminal stipules enclosing the bud, which are often reddish; also their leaves are entire and glabrous, while those of *Clerodendron* seedlings are serrate and pubescent.

Silvicultural characters. Although seedlings spring up under moderate shade, and require protection from drought, from the sapling stage onwards the tree is a strong light-demander. Saplings are sensitive to the rubbing of their leading shoots by overhead trees, and their leaders tend to die where this takes place. The soil requirements of the tree have already been alluded to: good drainage is essential for the best development, trees on stiff soil remaining stunted. Although the seedlings are sensitive to drought the tree is moderately hardy; it was only slightly affected in the abnormal droughts of 1899 and 1900 in the Indian Peninsula and 1907 and 1908 in Oudh. After the seedling stage it is moderately frost-hardy, having suffered only to a slight extent in the severe frost of 1905 in northern India. Young plants and coppice-shoots suffer more than those of almost any other species from browsing by cattle, goats, deer, and *nilgai*; they have good power of recovery,

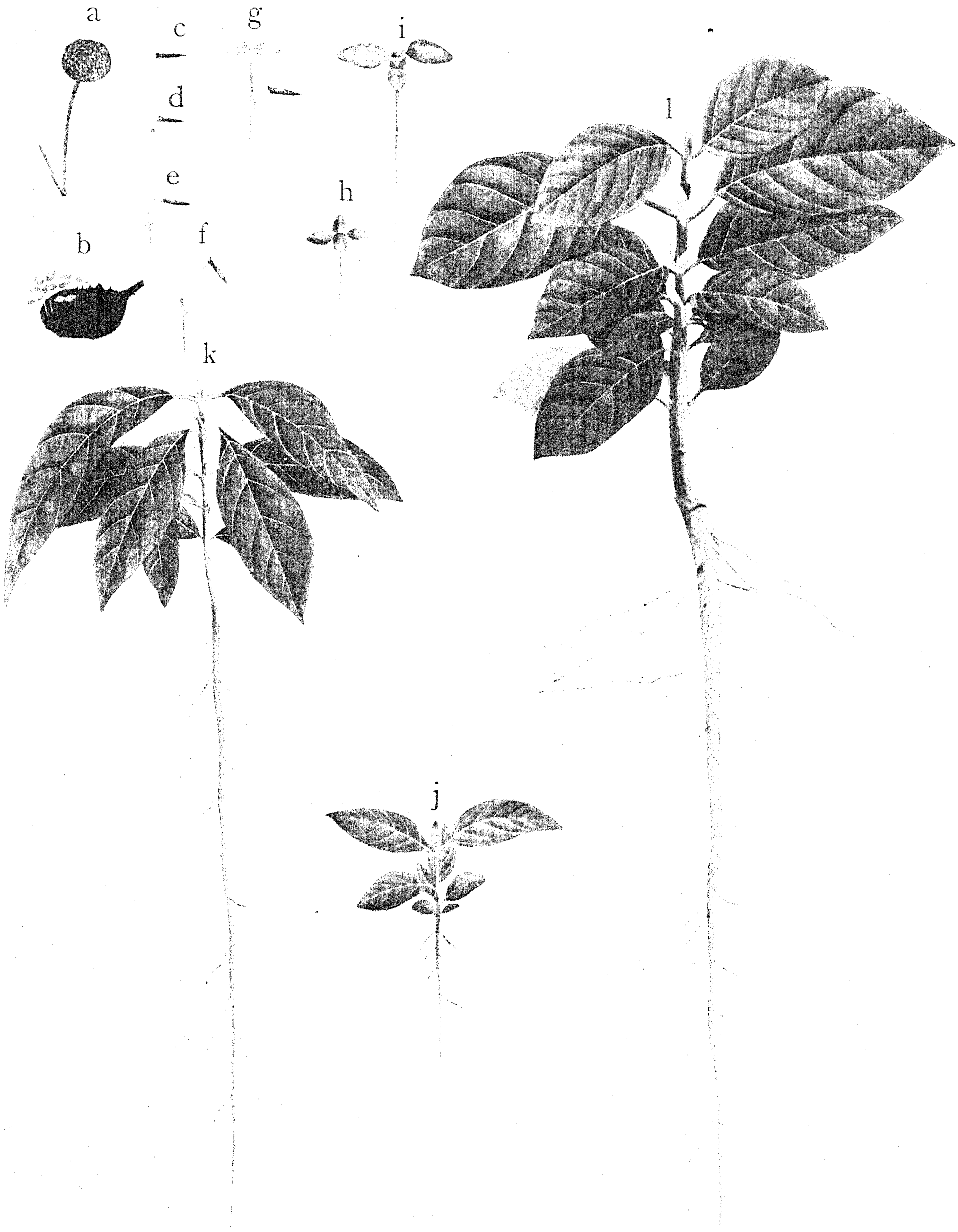

FIG. 237. *Adina cordifolia*—SEEDLING

a—Fruit-head × $\frac{3}{8}$ b—Fruit-head with germinating seedlings × $\frac{3}{4}$ c—Seed × 2 d - g—Germination stages × 2 h, i—Development of seedling to end of first season $\frac{1}{1}$ j - l—Development of seedling to end of second season × $\frac{3}{8}$ (Seedling raised artificially, and more vigorous than a natural seedling)

but remain in a bushy condition with repeated browsing. In some localities bison and sambhar do much damage by barking saplings. The tree coppices readily up to a moderate size, producing numbers of shoots, chiefly from the base of the stool.

Natural reproduction. The minute seeds, shed during the hot season, are often carried to a distance by the wind; in some cases the fruit-heads fall before all the seed is shed, and the seed may germinate within the fruit-heads. Germination takes place early in the rainy season. The seeds are produced in vast numbers, but the proportion of seedlings which survive and establish themselves is relatively very small. The chief reasons for this are: first, that the minute seeds and young seedlings are very liable to be washed away and so perish; and second, that the seedlings in their early stage are very delicate. It is often recorded that the natural reproduction of this species is almost entirely absent; this is, however, far from being the case, and such statements are probably as a rule the result of failure to recognize the seedlings.

For successful germination under natural conditions bare ground appears to be essential, whereas for the successful establishment of the young seedling it is necessary that the seeds, or perhaps even the young seedlings, should be washed up out of the reach of floods during the first rainy season, and find a lodgement in a well-drained situation where the seedlings are not liable to be inundated or washed away. Seedlings have actually been observed in greater or less abundance in the following situations: (1) on small landslips on hill slopes; young plants of all ages are often found on such ground at the base of the outer Himalaya; (2) in loose earth and débris at the base of the hills; where this material is washed out over natural well-drained terraces seedlings are often plentiful, and this no doubt explains the origin of the many large old trees found on the boulder terraces at the foot of the Himalaya; (3) on well-drained alluvial ground near rivers, and on flat ground generally, always provided the ground is bare and not covered with weeds when the seed germinates; on such ground seedlings may often be found in plenty on small natural humps or mounds, or round the bases of trees or termite heaps, where the seeds or young seedlings have been stranded during the rains; as many as eight small seedlings were counted in the slightly raised earth round the base of one sal tree on flat ground in the Gorakhpur forests, United Provinces; (4) on abandoned cultivation, for instance in *taungya* clearings in Burma, where natural reproduction often springs up in quantity; (5) on the sides of walls, embankments, and ditches; on the side of the boundary trench round the Birpur forest rest-house, Gonda, United Provinces, were observed numerous saplings sprung from seed washed on to the sides of the trench, probably on new ground when the trench was made; (6) round the edges of natural tanks and depressions where water lodges during the rains, the seeds being washed up out of the reach of floods and stranded; (7) on the sites of old charcoal kilns; seedlings often appear on these owing to the good drainage afforded; (8) occasionally in the form of epiphytes in forks of or hollows in trees; (9) in clefts in rocks; a seedling $1\frac{1}{2}$ ft. high and probably a few years old was found growing tightly wedged in a crack in a large sandstone boulder where there was no soil.

As regards light requirements, the young seedlings probably benefit from shade, provided this does not take the form of low weed-growth, since they are undoubtedly sensitive to drought. That they establish themselves well under moderate shade is certain from the fact that they may be found coming up in sal forest: numerous seedlings were observed thriving on bare alluvial ground under a well-thinned sissoo plantation in the Gorakhpur district, United Provinces, while in the same district seedlings, probably two or three years old, were found in plenty on bare ground under a light cover of *Flemingia Chappar*. That the admission of light greatly stimulates the establishment of natural reproduction is clear from the fact that in various parts of the sal forests of Oudh, where the canopy has been heavily opened out owing to the death of large numbers of trees during the abnormal drought of 1907 and 1908, *Adina* saplings have appeared in quantity because of the admission of light; no doubt many of these plants were present before the canopy was opened, but their growth since then has been greatly stimulated. A dense sal crop in the Gonda district was experimentally opened out in January 1911 in the form of a regeneration felling for the sal; the plot was inspected two years later, and found to contain numerous young *Adina* seedlings which had made their appearance owing to the admission of light.

Protection from grazing is essential for the successful establishment of natural production, owing to the readiness with which animals browse down the young plants.

ARTIFICIAL REPRODUCTION. As far as is known success has never been attained by means of direct sowings. Experiments at Dehra Dun, by which seed was sown broadcast on hoed ground, as well as on ridges and in trenches, failed entirely, any seed which did germinate being washed away before the seedlings could gain a footing. In the United Provinces broadcast sowings on hoed ground have been tried from time to time, but failure has always been recorded.

Experiments at Dehra Dun have shown that seedlings can be grown successfully in well-raised beds of fine sifted soil with a considerable proportion of sand, or better still on powdered charcoal, but it is essential that the beds should be covered with screens raised about a foot above them, in order to keep off rain and sun, and that watering should be done with a very fine spray. Seed-boxes, however, have proved more successful than seed-beds, and considering the large number of seedlings obtainable from one box there is little question that raising in boxes is to be recommended in preference to any other method. The following procedure has given good results:

The seed-box is filled to within about 1 in. from the top with finely sifted earth with a large proportion of sand, the surface is made smooth and watered, and the seeds are sown about April or May on the wet surface and very lightly covered with fine earth or sand. The box should be kept under cover, and watering with a very fine spray should be done frequently but sparingly. Germination ordinarily takes place in about three to six weeks. As soon as the seedlings are large enough to handle, that is, in about two to three months, they should be pricked out about 2 in. apart in boxes; the more vigorous ones may even be pricked out about 4 in. apart in nursery-beds. The seedlings will be ready to plant out in the forest early the following rains. Transplanting

FIG. 238. *Stephegyne parvifolia*, height 78 ft., girth 27 ft. 6 in., Siwalik hills, United Provinces.

is not unattended with risk owing to the liability of the seedlings to die of drought; care is therefore necessary to keep a ball of earth round the roots. Risk is further avoided by pricking out the plants into baskets or bamboo tubes instead of into boxes or nursery-beds, so that there is no interference with the roots during transplanting. After transplanting it is advisable to keep the soil round the plants well loosened and free from weeds in order to stimulate vigorous growth and to prevent caking of the ground.

RATE OF GROWTH. The following results of girth measurements in high forest sample plots are available:

Adina cordifolia: girth increment in high forest sample plots.

Province.	Forest division.	Locality.	Number of years under measurement.	Number of trees under measurement.	Girth classes. ft.	Mean annual girth increment for period. in.
United Provinces	Saharanpur	Dholkhand	7	1	3–4	1·0
	Lansdowne	Giwain	4	1	$1\frac{1}{2}$–3	0·97
			12	3	$1\frac{1}{2}$–3	0·27
	Gonda	Chandanpur	2	4	$1\frac{1}{2}$–3	0·51
	S. Kheri	Bhira	11	1	1–2	0·72
Central Provinces	Balaghat	Raigarh and Baihar	8	1	2–3	0·53
				1	4–5	0·19

Coppice measurements by Mr. C. M. McCrie in 1910 in the Gorakhpur district, United Provinces, showed an average height and girth of 18·7 ft. and 6·9 in. respectively in seven years, as compared with an average height and girth of 10·2 ft. and 3·87 in. respectively for sal in the same coupe.

Measurements of coppice-shoots on somewhat poor stony ground in the Saitba block, Kolhan forest division, Chota Nagpur, gave the following results:

Adina cordifolia: coppice measurements, Saitba block, Kolhan.

Age. years.	Mean girth. in.	Mean height. ft.	Age. years.	Mean girth. in.	Mean height. ft.
2	—	3·0	10	5·5	13·5
4	3·0	6·5	12	6·1	15·0
6	4·0	9·0	14	6·6	16·5
8	4·8	11·5			

3. STEPHEGYNE, Korth.

Species 1. *S. parvifolia*, Korth.; 2. *S. diversifolia*, Hook. f.

1. **Stephegyne parvifolia**, Korth. Syn. *Nauclea parvifolia*, Willd.; *Mitragyna parvifolia*, Korth. Vern. *Kaem, phaldu*, Hind.; *Kalamb*, Mar.; *Kadawar, yetega*, Kan.; *Chinna kadambu*, Tam.; *Rattaganapa*, Tel.; *Tein, teinthè*, Burm.

A large deciduous tree with a full rounded crown and a bole often short, fluted, and buttressed. Bark up to 0·8 in. thick, grey, smooth, exfoliating in scales which leave shallow depressions. Wood light pinkish brown, even grained, used for building, furniture, agricultural implements, bobbins, combs, cups, spoons, and other carved and turned articles; it is less in demand than that of *Adina cordifolia*. Under favourable conditions the tree reaches large dimensions: Fig. 238 shows a tree on alluvial ground in the Siwalik hills 27 ft. 6 in. in girth and 78 ft. high.

DISTRIBUTION AND HABITAT. Throughout the greater part of India and Burma, ascending to 4,000 ft. in the outer Himalaya; also in Ceylon. Not

reported from north and east Bengal or Assam. Within its habitat the tree is scattered in deciduous forests, not as a rule in any great abundance. Like *Adina cordifolia*, with which it is often associated, it reaches its best development on well-drained ground with deep soil. It is, however, more tolerant of stiff badly-drained ground than *Adina*, and often grows more or less gregariously on low-lying ground with clayey soil, for example on badly-drained savannah lands in Burma, and in many localities round the edges of tanks and swamps; in the *tarai* and plains of the sub-Himalayan tract it occurs frequently in low-lying somewhat swampy ground along with *Eugenia Jambolana*. In such places, however, its development suffers, and as a rule it remains stunted. In the Indian Peninsula it is often found on black cotton soil, and on alluvial ground near rivers.

In its natural habitat the absolute maximum shade temperature varies from 100° to 118° F., the absolute minimum from 30° to 55° F., and the normal rainfall from 35 to 130 in.

LEAF-SHEDDING, FLOWERING, AND FRUITING. The leaves are shed about February–March, and the tree is leafless in April–May, the new leaves appearing about May (northern India). The fragrant globose white or pale yellow flower-heads, 0·7–1 in. in diameter, appear from May to July, and the fruit-heads become full formed, but are still green and unripe, by October; in northern India they do not ripen and shed their seeds until about April–May. Haines mentions that ripe seed has also been collected in November in Chota Nagpur. The fruit-heads (Fig. 239, *a*) are globose, 0·5–0·7 in. in diameter, with numerous small two-valved many-seeded capsules. Sometimes the ripe fruit-heads fall before shedding the seeds, which may even be found germinating within the fallen fruit-heads (Fig. 239, *b*). The seeds (Fig. 239, *c*) are minute, 0·1–0·15 in. long, pointed at either end, light brown, very light, as many as 10,000 weighing 1 gramme, giving nearly 300,000 to the ounce avoirdupois.

GERMINATION (Fig. 239, *d–f*). Epigeous. The testa splits at one end and the minute radicle emerges, the hypocotyl elongates, arching slightly at first, and the testa, enclosing the cotyledons, is carried above ground, falling with their expansion.

THE SEEDLING (Fig. 239).

Roots: primary root in first season very fine, white and delicate, with a dense mass of woolly hairs in the upper part which soon disappears; in second season much thickened, terete, tapering: lateral roots moderate in number and length, fibrous, distributed down main root. *Hypocotyl* distinct from root, 0·1–0·15 in. long, very fine and delicate, white turning green. *Cotyledons* very shortly petiolate, up to 0·1 in. long, ovate, acute or rounded, base rounded, truncate or sub-cordate, entire, foliaceous, glabrous. *Stem* erect, delicate at first, becoming woody later; internodes in first season very short, in second season up to 1 in. long. *Leaves* simple, opposite decussate. Leaves of first season usually only two pairs, sub-sessile or very shortly petiolate, 0·1–0·5 in. by 0·08–0·4 in., ovate, acute or rounded, base obtuse or acute, entire, often reddish.

Like those of *Adina cordifolia*, which they strongly resemble, the seedlings for some little time after germinating are extremely minute and delicate, and are very liable to be beaten down or washed away by rain. During the first season their growth is very slow, a height of barely ½ in. being ordinarily

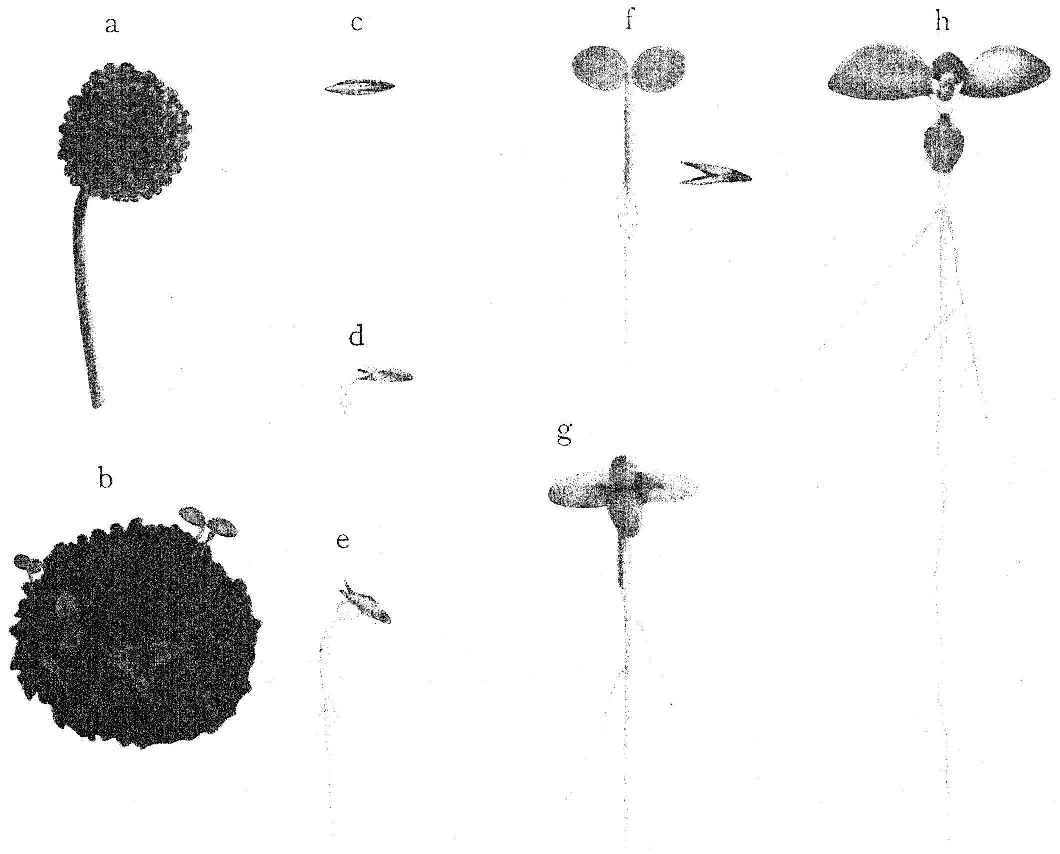

FIG. 239. *Stephegyne parvifolia*—SEEDLING

a—Fruit-head × ½ b—Old fruit-head with seedlings germinating × 2 c—Seed × 5 d - f—Germination stages × 5
g - h—Development of seedling to end of first season × 3

attained by the end of the season, and usually about two pairs of foliage leaves being produced.

SILVICULTURAL CHARACTERS. In early youth the tree stands a certain amount of shade, seedlings and saplings being often found under cover, but later it is a light-demander: as in the case of *Adina cordifolia*, saplings are sensitive to the rubbing of their leading shoots by overhead trees. As already mentioned, the tree is capable of growing on badly-drained ground, but its growth suffers in such places. It is fairly hardy against drought, having suffered only to a slight extent in the abnormal droughts of 1907 and 1908 in Oudh, and 1899 and 1900 in the Indian Peninsula. The tree coppices well up to a moderate size. In some localities bison are apt to damage poles of this species by stripping the bark off them.

NATURAL REPRODUCTION. So far as the natural reproduction of this tree has been studied, the conditions influencing it appear to be very similar to if not identical with those affecting the reproduction of *Adina cordifolia*. As in the case of the latter species, the minute seeds are scattered in the hot season, some remaining in the fruit-heads and germinating in them after they fall to the ground, and reproduction springs up in places similar to those in which *Adina cordifolia* reproduction appears, seedlings of the two species being often found together. The survival of reproduction on badly-drained ground is, however, more marked than in the case of *Adina*. Natural reproduction sometimes comes up fairly freely on abandoned cultivation.

ARTIFICIAL REPRODUCTION. According to experiments carried out at Dehra Dun, the most satisfactory method of raising this tree artificially is in boxes, the procedure followed being exactly the same as that described for *Adina cordifolia* (p. 620).

RATE OF GROWTH. The following results are available of high forest sample plot measurements in the Singhbhum forest division, Chota Nagpur:

Stephegyne parvifolia: girth increments in high forest sample plots, Singhbhum.

Locality.	Number of years under measurement.	Number of trees under measurement.	Girth classes.	Mean annual girth increment for period.
			ft.	in.
Tirilposi block	18	1	5–6	0·58
		2	6–7	0·54
Samta-Hendakuli old road	10	1	6–7	0·37
		2	7–8	0·25

A cross-section 3 ft. 10 in. in girth in the silvicultural museum at Dehra Dun showed 61 rings, representing a mean annual girth increment of 0·75 in. Gamble's specimens showed 5 to 15, averaging 9, rings per inch of radius, representing mean annual girth increments of 0·42 to 1·26, averaging 0·7 in., which is moderate.

Coppice measurements made in 1910 by Mr. C. M. McCrie in the Gorakhpur district, United Provinces, gave the following results for *Stephegyne* as compared with sal:

Stephegyne parvifolia: coppice measurements, Gorakhpur.

Age.	Mean girth. *Stephegyne.*	Sal.	Mean height. *Stephegyne.*	Sal.
years.	in.	in.	ft.	ft.
2	—	—	4·5	3·0
4	2·2	2·0	9·0	7·0
6	3·3	2·9	12·0	10·3
8	4·2	3·8	14·0	13·0
10	5·0	4·8	16·0	15·3
12	5·8	5·8	18·0	17·5

2. **Stephegyne diversifolia**, Hook. f. Syn. *Nauclea rotundifolia*, Roxb. Vern. *Binga*, Burm.; *Hnawthein*, U. Burm.

A moderate-sized to large deciduous tree with large nearly orbicular leaves, found in Burma, the Andamans, and Chittagong; also in Java and the Philippines. The tree is a very common one in the mixed deciduous forests of Burma, both of the upper and of the lower type. In the lower mixed forests on flat alluvial land it is often found in great abundance. Thus in the Thindawyo reserve in the Tharrawaddy district enumerations showed it to be the commonest species in the forest, an average of 118 trees 3 ft. in girth and over being counted per 100 acres.[1] The seeds are minute, like those of *S. parvifolia* and *Adina cordifolia*, and a further study of the tree will no doubt reveal points of similarity to those two species in matters relating to reproduction. Natural reproduction is often abundant on alluvial ground along rivers and streams. The Burma Forest Report for 1914–15 mentions that natural seedlings appeared freely in the Yetkanzin reserve, Toungoo, in an area where bamboos had flowered and which had been fire-protected for many years and burnt when the bamboos flowered; the reproduction was the result of the burning, which would indicate that clear ground, as in the case of *S. parvifolia* and *Adina cordifolia*, is a favourable factor. It often comes up in abundance on abandoned cultivation. Mr. A. Rodger[2] in 1916 enumerated a dense pole crop on an old *taungya* cultivated about seventeen years previously in the Prome district of Burma. The enumeration showed 1,150 stems per acre, of which 72 per cent. consisted of *Stephegyne diversifolia*.

4. NAUCLEA, Linn.

Nauclea sessilifolia, Roxb. Syn. *Adina sessilifolia*, Hook. f. Vern. *Tein-kala*, Burm.

A large deciduous tree of Cachar, Chittagong, and Burma, occurring in mixed deciduous forests. In Burma it is particularly common in some of the lower mixed forests on flat alluvial ground. Enumerations in the Thindawyo reserve of the Tharrawaddy district showed that after *Stephegyne diversifolia* it was more plentiful than any other species enumerated, showing an average of 98 trees 3 ft. in girth and over per 100 acres.[1] On flat alluvial ground by rivers and streams natural reproduction often springs up in great quantity,

[1] Working Plan for the Satpôk, Sitkwin, and Thindawyo Reserves, Tharrawaddy, Burma, 1906.

[2] Ind. Forester, xlii (1916), p. 499.

forming dense pure patches. The seeds are minute like those of *Adina cordifolia* and *Stephegyne diversifolia*, and a further study of this tree will probably reveal points of resemblance to those species, particularly as regards reproduction. The wood is used for planking and building.

5. HYMENODICTYON, Wall.

Hymenodictyon excelsum, Wall. Syn. *H. thyrsiflorum*, Wall.; *H. utile*, Wight; *Cinchona excelsa*, Roxb. Vern. *Kukurkat, bhaulan, bauranga*, Hind.; *Bhorsal*, Mar.; *Pottaka*, Tel.; *Kusan*, Burm.

A large deciduous tree, usually with a straight cylindrical bole and a rounded crown. Bark greyish brown, thick, soft, corky and furrowed on stems of older trees, smooth on poles and branches. Wood white when fresh, turning darker, soft, light, used for planking, boxes, scabbards, toys, &c.; has been reported as excellent for match manufacture. In northern India, however, the trees have often been noticed to be riddled with large burrows, probably those of a longicorn beetle, and the quality of the wood suffers in consequence.

DISTRIBUTION AND HABITAT. Scattered throughout the greater part of India and Burma in dry mixed deciduous forests. The tree is particularly common on loose dry deposits of boulders and débris along the base of the outer hills in the sub-Himalayan tract. It is one of the characteristic trees of the *bhabar* tract of the United Provinces, a deep boulder formation on gently sloping ground where the subsoil water-level is at a great depth; here among its commoner companions are *Holoptelea integrifolia, Lagerstroemia parvifolia, Acacia Catechu, Bombax malabaricum, Terminalia belerica, Adina cordifolia, Anogeissus latifolia, Cassia Fistula,* and *Odina Wodier.* It is also frequently met with on sandy or stony soils on alluvial ground near rivers, and in savannah lands. It is not infrequent in the sal forests of northern India.

In its natural habitat the absolute maximum shade temperature varies from 98° to 118° F., the absolute minimum from 30° to 60° F., and the normal rainfall from 35 to 90 in.

LEAF-SHEDDING, FLOWERING, AND FRUITING. The large broadly elliptical long-stalked leaves turn a rich yellow and fall in November–December at a time when few other trees are shedding their leaves. The new leaves do not appear until about May, and throughout the intervening months the leafless trees are conspicuous with their candelabra-like fruit-panicles subtended by pairs of dry leafy reddish brown bracts. The small white fragrant flowers, in large terminal panicles, appear from June to August. The capsules are conspicuous from November–December onwards, but do not open and shed their seeds until April–May: they are two-valved, ellipsoidal, 0·5–0·7 in. long, and contain many seeds.

The seeds (Fig. 240, *a*) are flat, winged all round the margin, 0·3 by 0·1 in. including the wing; they are very light, about 4,800 weighing 1 oz., and are disseminated to a distance by the hot weather winds. Tests carried out at Dehra Dun showed that the fertility of fresh seed is high, but that the seed loses its vitality within a year.

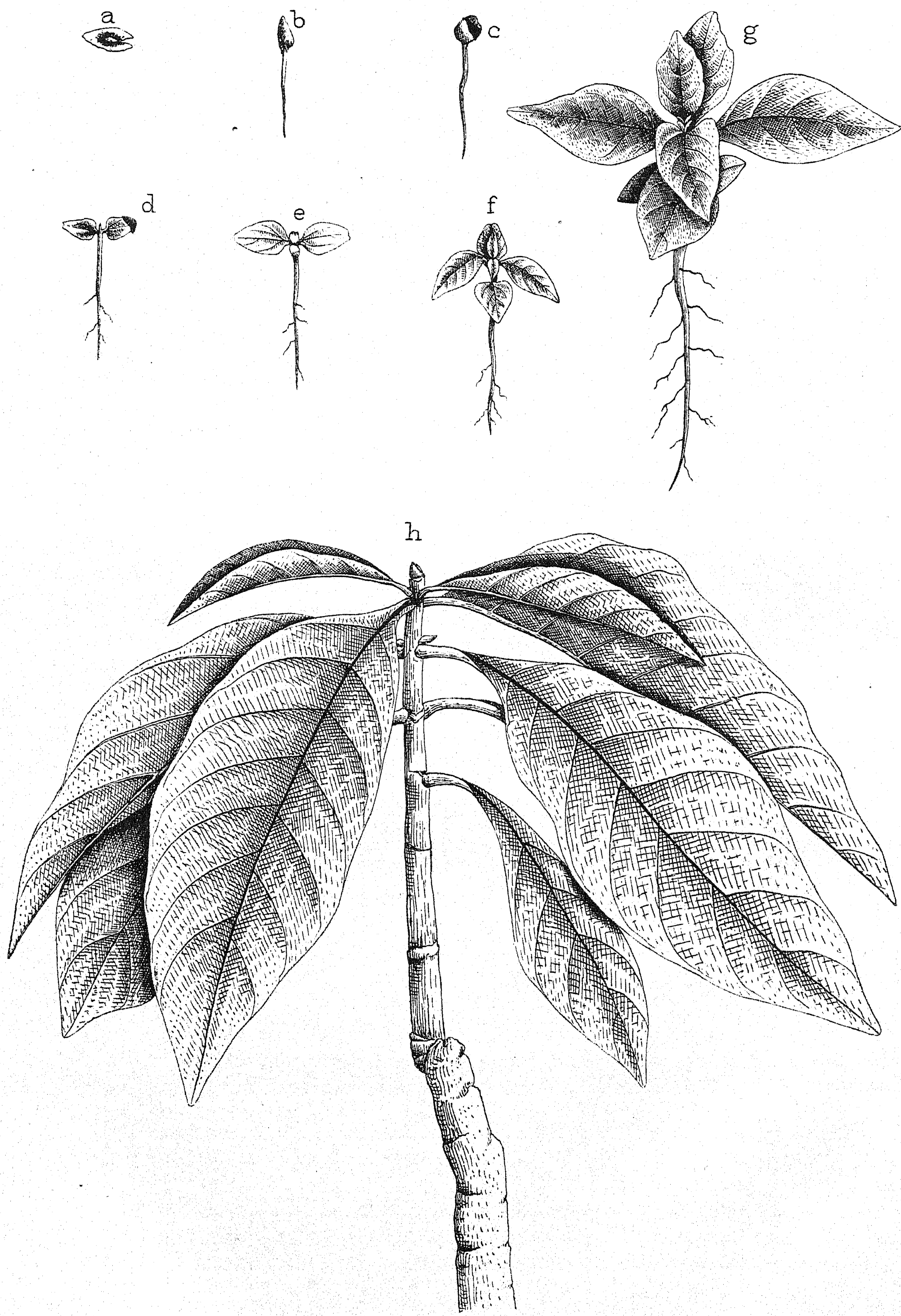

FIG. 240. *Hymenodictyon excelsum*. Seedling × $\frac{7}{8}$.

a, seed; *b–e*, germination stages; *f, g*, development of seedling during first season; *h*, seedling towards end of second season (long thick taproot not shown).

GERMINATION (Fig. 240, *b–e*). Epigeous. On the emergence of the radicle the hypocotyl elongates, carrying above ground the cotyledons enclosed in the testa. On the expansion of the cotyledons the testa usually remains for a time on the end of one of them, ultimately dropping to the ground.

THE SEEDLING (Fig. 240).

Roots: primary root long, thickening early and becoming very thick in second season, terete, tapering: lateral roots few to numerous, fibrous. *Hypocotyl* distinct from root, 0·3–0·5 in. long, cylindrical, green, minutely pubescent. *Cotyledons*: petiole up to 0·1 in. long, flattened above: lamina 0·35–0·5 in. by 0·25–0·3 in., foliaceous, ovate, emarginate, entire, glabrous, usually persisting till end of first season. *Stem* erect, minutely pubescent, in first season short, with internodes 0·1–0·2 in. long; in second season thick, woody, with internodes 0·4–1 in. long. *Leaves* simple, opposite decussate: stipules (first season) less than 0·1 in. long, triangular, pubescent: petiole (first season) 0·1 in. long, pubescent, midrib running prominently down upper side: lamina (first season) 0·8–1·8 in. by 0·6–1 in., sub-rhomboidal or ovate, acute, base tapering, entire, pubescent, venation arcuate, lateral veins 4–6 pairs, midrib often red.

The seedling develops very slowly above ground during the first season, and under natural conditions also during the second or third seasons, after which, if the plant survives, the growth is more rapid. As a rule a height of not more than 1 or 2 in. is attained during the first season, with not more than three to five pairs of leaves. The underground development, however, is considerable, a long stout taproot being quickly formed; this may be as much as 1 ft. 6 in. long by the end of the first season. This underground development, which is common among seedlings of trees characteristic of dry types of forest, is evidently an adaptation for the establishment of the plant before any marked growth in the stem begins.

The seedling is very sensitive to frost, especially during the first year or two while the plants are small; in localities subject to frost many seedlings are killed outright, while some may shoot up again from the base. Weeds impede the development of seedlings considerably, suppressing and killing them if heavy. The seedling is decidedly light-demanding. Growth ceases from November to May; the leaves turn yellow or reddish and drop in November–December, the plants being leafless from January to May, when the new leaves appear (northern India).

The following measurements in experimental plots at Dehra Dun give some indication of the rate of growth of young plants:

Hymenodictyon excelsum: development of seedlings, Dehra Dun.

Condition under which grown.	Height at end of season.			
	1st season.	2nd season.	3rd season.	4th season.
(1) Natural conditions	Maximum 0 ft. 1 in.	..	..	..
(2) Nursery, weeded and watered	„ 0 ft. 1½ in.	Maximum 1 ft. 3 in.	..	..
(3) Broadcast sowing, irrigated, unweeded	„ 0 ft. 2 in.	„ 0 ft. 3 in.[1]	Killed by weeds in 3rd season	..
(4) Broadcast sowing, unirrigated, unweeded	„ 0 ft. 1½ in.	„ 0 ft. 1½ in.[1]	Ditto	..
(5) Broadcast sowing, unirrigated, weeded	„ 0 ft. 2 in.	„ 0 ft. 4 in.[1]	10 in.–2 ft. 4 in.	Maximum 5 ft. 0in.

[1] New shoots from base; seedlings killed back by frost in previous winter.

Silvicultural characters. Except that the tree is known to be a strong light-demander its silvicultural characters have not been studied in detail.

Natural reproduction. Germination takes place during the rainy season. Bare ground is favourable to germination and subsequent survival, young seedlings being killed off in quantity where weeds are present. The small seedlings are liable to be washed away by heavy rain during and after germination, the seed is liable to destruction by insects, while the slow development of the seedling and its sensitiveness to weeds, frost, and shade are all contributory factors towards failure of natural reproduction, which explains to some extent its comparative scarcity in many localities.

Artificial reproduction. The artificial propagation of this tree is not easy. Direct sowings are not very suitable owing to the liability of the seed to be washed away and to the slow development of the seedling. Seed should be sown in the nursery in April and May in porous sandy loam, and lightly covered; the seedlings begin to appear in about eight to ten days. The beds require protection from heavy rain. The seedlings should be pricked out when about two or three months old and protected from frost in the winter. The more vigorous plants will be ready to plant out during the following rainy season, but the smaller ones should be kept another year in the nursery. Care is necessary to retain earth round the roots during transplanting, which may possibly be found more successful with the aid of long baskets or bamboo tubes.

Rate of growth. There are no detailed measurements available, but a cross-section from the United Provinces in the silvicultural museum at Dehra Dun had 41 rings for a girth of 3 ft. 11 in., giving a mean annual girth increment of 1·15 in., which is fairly fast.

6. WENDLANDIA, Bartl.

Wendlandia exserta, DC. Vern. *Chaulai*, *chila*, Hind.

A small deciduous or evergreen tree with greyish pubescent foliage, found locally in the sub-Himalayan tract, outer Himalaya, Chota Nagpur, and parts of the Indian Peninsula. It comes up gregariously on newly exposed ground, particularly on landslips and abandoned cultivation; the minute seeds appear to require such ground for successful germination. The tree is a useful one for reclothing bare hill slopes and clearings. It is strongly light-demanding. The growth is fast: Gamble's specimens gave 4 to 5 rings per inch of radius, or a mean annual girth increment of 1·26 to 1·57 in.

7. GARDENIA, Linn.

This genus contains about eleven Indian species of small trees or shrubs, most of which are interesting as being common members of dry open types of forest on poor ground on which many species are unable to exist. The wood of these trees deserves to be better known as a substitute for boxwood, being hard, close grained, and compact. The most widely distributed species is *G. turgida*, Roxb., described below. The species best known in the Indian Peninsula are *G. lucida*, Roxb., *G. gummifera*, Linn., and *G. latifolia*, Aiton. These are small trees or shrubs of xerophytic habit, growing on dry poor ground

often consisting of hard clay with quartz pebbles or calcareous nodules; they exude a clear fragrant yellow protective gum-resin which envelops the leaf-buds. The seeds of *G. latifolia* sometimes germinate in crevices in boulders and in forks or hollows of trees, and the plants grow and persist in such places: one plant was noticed in the Singhbhum district growing out of the side of a hollow *Bridelia retusa* tree about 10 ft. from the ground, appearing at first sight as if it had been grafted; the roots penetrated the inside of the *Bridelia* down to the ground.

In Burma various species of *Gardenia* are characteristic of *indaing* (dry dipterocarp) forest on laterite, or of open dry scrub forests; the better-known Burmese species are *G. turgida*, Roxb., *G. coronaria*, Ham., *G. erythroclada*, Kurz, *G. obtusifolia*, Roxb., and *G. sessiliflora*, Wall.

The gardenias are characterized by very fragrant tubular white flowers which appear mainly in the hot season and turn yellowish before falling. The fruits are fleshy, and those of some species at least are eaten by birds and animals, the seeds being disseminated by their agency. Sometimes dense clusters of young seedlings may be found on the ground, having sprung from seed which has germinated within the remains of fruits which have fallen from the tree.

The gardenias are comparatively immune from damage by grazing, and in grazed areas tend to become dominant owing to the extent to which most other species are kept down.

The rate of growth is slow to moderate. Gamble's specimens showed for *G. coronaria* 14 rings per inch of radius, giving a mean annual girth increment of 0·45 in., and for *G. latifolia* 8 rings per inch of radius, giving a mean annual girth increment 0·78 in. A cross-section of *G. latifolia* 1 ft. 0¼ in. in girth in the silvicultural museum at Dehra Dun had 28 rings, giving a mean annual girth increment of 0·44 in. A tree of the same species measured for a period of eight years in a sample plot in the Balaghat district, Central Provinces, showed a mean annual girth increment of 0·23 in.

Gardenia turgida, Roxb. Vern. *Thanela, karamba, ghurgia*, Hind.; *Bengeri*, Kan.; *Thaminsa-ni*, Burm.

A small deciduous tree with light grey or whitish smooth bark, rigid branches armed with sharp straight thorns, and leaves crowded at the ends of the branches. Wood hard, close grained, whitish.

Distribution and habitat. Throughout the greater part of India and Burma in dry open deciduous forests, ascending the outer Himalaya to 4,000 ft. The tree is characteristic of poor dry stony soil, dry rocky hill-sides, laterite, *kankar*, and also of stiff clayey soil. In Burma it is common in open *indaing* forests on laterite, in the open scrub forests of the dry zone, and in the dry deciduous forests of the Shan hills and elsewhere.

Leaf-shedding, flowering, and fruiting. The old leaves are shed about March, the new foliage appearing about May. The white dimorphic flowers, the females larger than the males, appear chiefly in March–April, when the trees are leafless or nearly so, and the fruits ripen and fall during the hot season a year later. The fruits are sub-globose, 1·5–3 in. in diameter, greyish green, with a thick rather hard pericarp and a woody endocarp, containing numerous angular seeds (Fig. 241, *a*) embedded in pulp. The germina-

tive power of the seed is fairly high: tests carried out at Dehra Dun gave a fertility of 77 per cent.

GERMINATION (Fig. 241, *b–g*). Epigeous. The radicle emerges from one end of the seed; the hypocotyl elongates by arching, and in straightening raises above ground the cotyledons enclosed in the testa, which falls to the ground on their expansion.

THE SEEDLING (Fig. 241).

Roots: primary root moderately long, at first thin, afterwards thickening, terete, tapering: lateral roots few to moderate in number, fibrous, distributed down main root. *Hypocotyl* distinct from root, 0·6–1 in. long, terete, tapering upwards, white turning green, minutely pubescent. *Cotyledons*: petiole less than 0·1 in. long, flattened above, minutely pubescent: lamina 0·8–0·9 in. by 0·5–0·6 in., foliaceous, ovate, acute, entire, green, glossy and glabrous above, glaucous and glabrescent or minutely pubescent beneath, margins sometimes fringed with fine hairs, venation arcuate. *Stem* erect, slightly compressed, pubescent, in first season short, with internodes up to 0·3 in. long. *Leaves* simple, opposite, sub-sessile or with short petioles bordered by the decurrent leaf-base: lamina up to 1 in. by 0·5 in., ovate, elliptical, obovate or oblanceolate, acute, base decurrent, entire, coriaceous, dark green and glossy above, paler beneath, both surfaces sparsely pubescent, margin with a fringe of fine hairs. Usually not more than two pairs of foliage leaves are produced in the first season.

The growth of the seedling during the first season is very slow, a height of only 1–2½ in. being attained. In the second season it is more rapid: nursery-raised seedlings at Dehra Dun attained a height of 1½ to 4½ ft. by the end of the second season, but under natural conditions, which are more unfavourable, the growth is probably much slower. The seedlings are decidedly frost-hardy.

SILVICULTURAL CHARACTERS. The tree is decidedly hardy as regards both frost and drought. On low-lying grassy land subject to severe frosts it is often one of the few species capable of existing. In the abnormal drought of 1907 and 1908 in the forests of Oudh it escaped injury when many other species were killed off in quantity. It is not readily browsed, even by goats.

NATURAL REPRODUCTION. The fruits are eaten by birds and animals, and the seeds are scattered by their agency. Those which are not eaten lie on the ground, turning brown and drying up somewhat in the hot season, and becoming partially eaten by white ants, or gradually rotting in the rainy season; in this case most if not all of the seeds lie ungerminated until the second rainy season, when germination takes place.

ARTIFICIAL REPRODUCTION. There is little difficulty in raising this species in the nursery and transplanting it. The seed should be sown about March or April: germination is rather slow, the seedlings usually appearing about six weeks to two months or more after sowing. The seedlings should be pricked out during the first rainy season and transplanted early in the second rains.

RATE OF GROWTH. The growth is slow to moderate. A cross-section from the United Provinces in the silvicultural museum at Dehra Dun showed 37 rings for a girth of 2 ft. 1½ in., giving a mean annual girth increment of 0·7 in. Gamble's specimens averaged 13 rings per inch of radius, giving a mean annual girth increment of 0·48 in.

Fig. 241. *Gardenia turgida*. Seedling $\frac{1}{1}$.
a, seed ; *b–g*, germination stages ; *h*, *i*, development of seedling to end of first season.

8. RANDIA, Linn.

This genus contains about fifteen Indian species of shrubs or small trees, some armed and others unarmed, some evergreen and others deciduous. Most of them have hard whitish close-grained woods suitable as substitutes for boxwood. The two species most commonly met with are *R. uliginosa*, DC., and *R. dumetorum*, Lam. A third, *R. malabarica*, Lam., is a thorny evergreen shrub common in the dry scrub forests in parts of the Indian Peninsula, often on laterite.

The better-known species of *Randia*, unlike the gardenias, appear to be very subject to browsing, especially by goats; this is certainly the case with *R. dumetorum*, *R. malabarica*, and *R. tetrasperma*, Roxb., a Himalayan species which is browsed down to a dense compact bush.

Species 1. *R. uliginosa*, DC.; 2. *R. dumetorum*, Lam.

1. **Randia uliginosa,** DC. Syn. *Gardenia uliginosa*, Retz. Vern. *Pindara*, Hind.; *Hmanbyu*, Burm.

A small deciduous rigid armed tree with reddish brown bark and quadrangular branches, common throughout the greater part of India and Burma, particularly on low-lying swampy ground and savannah lands; also on black cotton soil in the Indian Peninsula. It produces root-suckers freely, and is hardy against frost and drought; in the abnormal drought of 1907 and 1908 in the forests of Oudh it escaped untouched. The tree is leafless as a rule from February to April. The fruit, which ripens about February–March (northern India), is an ellipsoidal berry, 2–2·5 in. long, yellow when thoroughly ripe, with about twelve seeds embedded in a somewhat soft pulp (the swollen placentas) in two cells within a somewhat leathery pericarp. The seeds are dark brown, hard, shining, obscurely angular, 0·15–2 in. long. The growth of the young seedling is very slow. At Dehra Dun a height of less than 1 in. was attained by the end of the first season; by the end of the third season, however, plants attained a height of 7 ft. The rate of growth is moderate. A cross-section in the silvicultural museum at Dehra Dun showed 56 rings for a girth of 2 ft. 7½ in., giving a mean annual girth increment of 0·56 in. Gamble's specimens gave 6 to 7 rings per inch of radius, representing a mean annual girth increment of 0·9 to 1·05 in.

2. **Randia dumetorum,** Lam., including *R. longispina*, DC., and *R. nutans*, DC. Vern. *Mainphal*, Hind.; *Sethanbaya*, *thaminsa*, Burm.

A large shrub or small tree armed with straight axillary thorns and leaves in fascicles along the branches, extremely common as an undergrowth species in the sal forests of the sub-Himalayan tract, and common also in many parts of the Indian Peninsula and Burma, where it extends into the dry zone. It is a drought-hardy species, having resisted well the abnormal drought of 1907 and 1908 in the forests of Oudh. It is readily browsed by goats. It produces root-suckers. The fruit is a globose or ovoid berry, 1–1·5 in. long, yellow when ripe, containing a number of more or less angular seeds embedded in pulp; the fruits ripen in the cold season. As regards rate of growth, a cross-section in the silvicultural museum at Dehra Dun showed 26 rings for a girth of 1 ft. 4 in., giving a mean annual girth increment of 0·62 in. Gamble's specimens averaged 7 rings per inch of radius, representing a mean annual girth increment of 0·9 in.

ORDER XXXIV. ERICACEAE

This order is not of great importance in Indian forestry, though two species, *Rhododendron arboreum*, Sm., and *Pieris ovalifolia*, D. Don., are familiar trees in the Himalaya and other hill regions, where they are useful in clothing hill-sides and acting as nurses to more valuable species. All the Indian species of this order, of which at least forty belong to the genus *Rhododendron*, are trees or shrubs of the hills, many ascending to high elevations.

Genera 1. Rhododendron, Linn.; 2. Pieris, D. Don.

1. RHODODENDRON, Linn.

Rhododendron arboreum, Sm. Vern. *Chahan*, Haz.; *Chiu*, *buráns*, W. Him.; *Zalatni*, Burm.

A small evergreen tree, often with a somewhat crooked or gnarled trunk. Bark soft, easily cut through with a pocket-knife, 0·5–1 in. thick, old bark grey, exfoliating in irregular longitudinal plates, exposing the smooth pinkish new bark beneath. The wood is of inferior quality, both as timber and as fuel.

Distribution and habitat. This is a common tree in the western Himalaya, occurring chiefly at 5,000–8,000 ft. in association with *Quercus incana* and *Pieris ovalifolia*, and at the lower elevations with *Pinus longifolia*, but ascending to 11,000 ft. or even higher. It is somewhat rare in Hazara, being commonest in the Siran *Pinus longifolia* forests at 4,000 ft. and upwards in moist ravines. It extends to the eastern Himalaya, where, however, it is less common; it is also found in the Khasi hills and the hills of Burma, southern India, and Ceylon.

Flowering and fruiting. The large showy crimson, sometimes pink, flowers in dense corymbs appear usually from March to May, but in certain years only partial flowering takes place then, and a second flowering takes place in June or July; this happened in the Simla hills in 1916, following an exceptionally dry winter and spring, and the flowers of the second bloom were paler in colour than usual. Similar late flowering is also said to take place if the first bloom is checked by hail or other injury. Occasionally trees may be seen in flower in January–February. The fertilization of the flowers is carried out partly by insects. Mr. G. B. F. Muir notes an interesting case observed in Tehri Garwhal of Indian martens (*Martes flavigula*) visiting one cluster of flowers after another and thrusting their noses into the flowers to lick up the nectar; fertilization is thus carried out by their agency, and possibly birds may also be agents in cross-fertilization.

The capsules (Fig. 242, *a*) are 0·8–1·1 in. long by 0·3–0·4 in. in diameter, oblong, curved, greenish brown when ripening, then turning brown. They contain a large number of minute dark brown compressed oblong seeds about 0·05 in. long, with a fimbriate tuft at either end (Fig. 242, *b*). The capsules open and shed their seeds chiefly from January to March (western Himalaya). The open capsules as a rule remain many months on the tree.

Germination (Fig. 242, *c*–*e*). Epigeous. The radicle emerges from one end of the seed and descends. The hypocotyl elongates, arching slightly, and

the testa is carried above ground over the cotyledons, falling to the ground with their expansion.

THE SEEDLING (Fig. 242).

Roots: primary root terete, tapering, short and delicate for about two years, subsequently long and wiry: lateral roots at first few, short, afterwards numerous, moderately long, fibrous, distributed down main root.

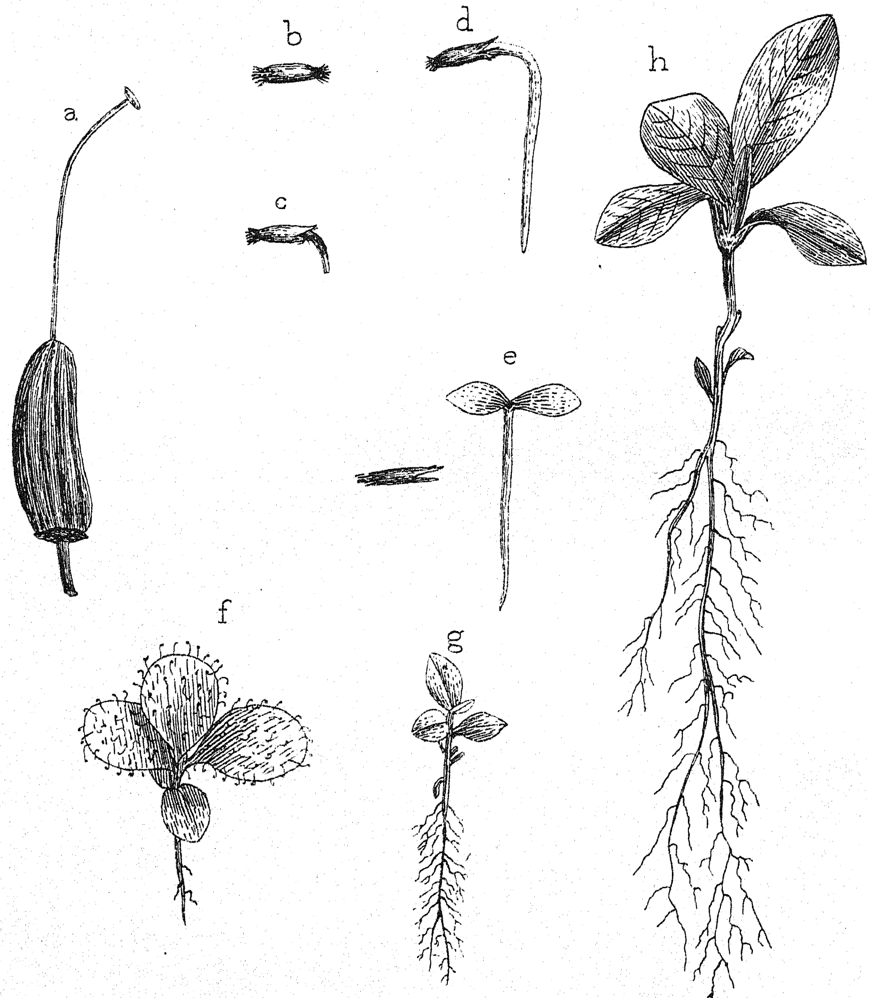

FIG. 242. *Rhododendron arboreum*. Seedling.

a, capsule $\frac{1}{1}$; *b*, seed $\times 5$; *c–e*, germination stages $\times 5$; *f*, seedling towards end of first season $\times 5$; *g*, seedling in third season $\frac{1}{1}$; *h*, seedling in fourth season $\frac{1}{1}$.

Hypocotyl distinct from root, up to 0·1 in. long, terete, cylindrical or tapering slightly upwards, green, glabrous. *Cotyledons* up to 0·06 in. by 0·04 in., foliaceous, slightly fleshy, sub-sessile, elliptical or almost orbicular, acute, obtuse or rounded, minutely and somewhat widely serrulate, often turning red in the autumn. *Stem* erect, very short during first two years, elongating slowly during the next few years. *Leaves* simple, alternate, in first season shortly petiolate, up to 0·12 in. by 0·1 in., broadly ovate or orbicular, mucronate, entire, upper surface and margins covered with stiff glandular hairs,

leaves sometimes turning dark red in autumn: leaves gradually increase in size from second season onwards, becoming elliptical, coriaceous, entire, the upper surface and margins still covered with stiff glandular hairs, at any rate on young leaves, for the first three or four years.

During the first season the seedling is minute, reaching a height of scarcely 0·1 in., with 2 or 3 foliage leaves besides the cotyledons. For the first few years the growth is very slow. The seedling is very sensitive to drought, and survives in moist well-drained places, such as damp shady banks, cuttings, and rocks.

Silvicultural characters. The tree stands a fair amount of shade, but develops best in the open. It will grow on rocky ground provided there is sufficient soil moisture, but thrives best on moist loam. It coppices well.

Natural reproduction. Natural reproduction springs up readily on newly exposed ground such as road-cuttings and landslips and in the crevices of bare rocks. In such places seedlings of various ages may often be found in large quantities provided the soil is moist; natural reproduction does not appear in dry places, as the seedlings perish quickly from drought.

Artificial reproduction. Seedlings may be raised artificially by sowing seed in March or April in boxes or pots filled with fine sand or powdered brick previously soaked with water; the seeds should not be covered. The boxes or pots should be sheltered from rain and sun and watered regularly. The seedlings may be pricked out, if large enough, in the second season, and kept in the nursery until sufficiently large to plant out.

A more satisfactory method of planting is to dig up seedlings from the banks and cuttings on which they spring up naturally and transfer them to the nursery, keeping them there until large enough to plant out.

Rate of growth. The annual rings are not always distinct, but where visible they show a slow rate of growth. Brandis gives 14 rings per inch of radius, while Gamble's specimens varied from 12 rings in the western Himalaya and the Nilgiris to as many as 36 in Sikkim, representing a mean annual girth increment varying from 0·17 to 0·52 in.

Coppice growth, though usually faster for a time than that of *Quercus incana*, is slow. Measurements made in 1911 in a coppice coupe six years old at Bhowali near Naini Tal (elevation 5,600 ft.) showed an average of 5 shoots per stool and a mean height of 4 ft. 4 in.

2. PIERIS, D. Don.

Pieris ovalifolia, D. Don. Syn. *Andromeda ovalifolia,* Wall. Vern. *Ayar,* Hind.; *Ailan,* Pb.

A small deciduous tree. Bark brown, thick, fibrous, exfoliating in long narrow strips, deeply furrowed longitudinally, the furrows often proceeding spirally up the stem. This is a familiar tree in the western Himalaya at 4,000–8,000 ft., chiefly on grassy slopes in association with *Quercus incana* and *Rhododendron arboreum*, or at the lower elevations with *Pinus longifolia.* In Hazara it is rare except in the *Pinus longifolia* forests of the Siran valley, where it is fairly common at 4,000 ft. and upwards. It is also found in the eastern Himalaya, descending to 2,000 ft. in the Tista valley, the Khasi hills, and the hills of Burma. The wood is of little value either as timber or as fuel,

but the tree is useful in covering hill slopes, and in the western Himalaya in acting as a nurse to the deodar. It is fire-resisting and is not browsed by cattle: the leaves are said to be poisonous to goats and camels. The racemes of heath-like white honey-scented flowers appear from April to June (western Himalaya), and the capsules, containing numerous minute seeds, begin to ripen about December, dehiscing from January to March. The tree coppices well, the coppice growing faster than that of *Quercus incana*. Measurements in 1911 in a coppice coupe six years old at Bhowali near Naini Tal showed an average of 8 shoots per stool and a mean height of 5 ft. 1 in., as compared with 4 ft. 3 in. for the oak. Gamble gives the rate of growth as 12 to 18 rings per inch of radius in the west, representing a mean annual girth increment of 0·35 to 0·52 in., and about 6 rings in the east, representing a mean annual girth increment of 1·05 in.

ORDER XXXV. MYRSINACEAE

AEGICERAS, Gaertn.

Aegiceras majus, Gaertn. Syn. *A. corniculata*, Blanco. Vern. *Kulsi*, Beng.; *Kanjala*, Mar.; *Butalet*, Burm.

A large evergreen glabrous shrub or small tree with grey bark, common in the mangrove forests along tidal creeks, where it is frequently gregarious. It is one of the most widely distributed species of this formation, occurring at the mouth of the Indus, along both sides of the Indian Peninsula, in the Sundarbans and along the coasts of Chittagong, Arakan, Burma, and the Andamans. Like the true mangroves this tree exhibits vivipary, the seed germinating within the pericarp of the curved horn-shaped fruit. The tree coppices well. The wood is used for small building material and for fuel.

ORDER XXXVI. SAPOTACEAE

An important order of forest trees, some furnishing useful timbers, others edible flowers and fruits and oil-seeds, others latex of commercial value. The two genera of most importance in Indian forestry are *Bassia* and *Mimusops*. The gutta-percha of commerce is furnished by the latex of certain species of *Palaquium* (syn. *Dichopsis*, *Isonandra*) and *Payena*, found in the Malay Peninsula and Archipelago; both these genera are represented in India, though none of the Indian species are known to yield gutta-percha of good quality. The two most important gutta-percha producing species in the Malayan region are *Palaquium Gutta*, Burck., and *P. oblongifolium*, Burck.

An interesting account of the gutta-percha forests of the Malay States is given in the *Indian Forester*, vol. xxxi (1905), p. 309, by Mr. A. M. Burn-Murdoch, who points out that gutta-percha is derived almost entirely from trees growing within 6 or 7 degrees of the Equator. Apart from the two species of *Palaquium* already mentioned, gutta-percha of good quality is yielded by *Payena Laerii*, which species, however, is not abundant. An inferior latex is produced by *Palaquium pustulatum*. Referring to *P. Gutta*, including *P. oblongifolium*, which is very similar and is not always considered to be

specifically distinct, Mr. Burn-Murdoch notes that the tree is easily recognized by its leaves, which are coriaceous, oblong or obovate-oblong, about 2 in. long in mature plants but much longer in young plants, dark glossy green above and a beautiful coppery gold colour beneath. The tree occurs most frequently on the low hills and plains, often on steep hill-sides, up to 2,000 ft. and even 3,000 ft. above sea-level. During the latter half of last century the trees large enough to yield gutta-percha were practically exterminated ; from about 1898 onwards steps were taken to conserve the existing stock, which, however, was by that time found to consist of little except immature trees. The tree is a pronounced shade-bearer and is able to maintain the struggle for existence successfully, if slowly, in the dense evergreen forests in which it grows. Its growth is slow. Natural seedlings are often plentiful, but in the overworked areas many of the young plants are found to be coppice-shoots.

At the time Mr. Burn-Murdoch wrote regular plantations were found to be impossible in the Federated Malay States for want of seed, and the method followed by the Forest Department was to cut lines through the dense undergrowth and to transplant into these lines young natural seedlings taken from outside the reserved forests or from congested clumps of reproduction within those forests. In addition improvement fellings are carried out to assist poles and saplings, and undergrowth is cleared once a year or at longer intervals, as may be found necessary, over natural seedlings or transplants : these measures have been found to produce very beneficial results. The chief damage to this tree is caused by the larva of a moth (*Rhodoneura myrsusatis*, Wlk. ?) which eats the young shoots and leaves ; the damage is more extensive in pure plantations than in the case of isolated plants under natural conditions.

Genera 1. Mimusops, Linn. ; 2. Bassia, Linn.

1. MIMUSOPS, Linn.

Species 1. *M. Elengi*, Linn. ; 2. *M. hexandra*, Roxb. ; 3. *M. littoralis*, Kurz.

1. **Mimusops Elengi**, Linn. Vern. *Mulsári*, Hind. ; *Bukal*, Beng. ; *Owli*, Mar. ; *Bukul*, Kan. ; *Mahila, magadam*, Tam. ; *Elengi*, Mal. ; *Kaya*, Burm.

A large evergreen tree with a dense crown of shiny coriaceous leaves with undulate margins. Bark dark grey, scaly. Wood very hard, with dark red heartwood, heavy, strong, and durable, used for building, rice-pounders, &c. The fruit is eaten and the seeds yield an oil used for cooking and lighting and in medicine. Under favourable conditions the tree reaches large dimensions, with a long cylindrical bole.

Distribution and habitat. The Indian Peninsula along the Western Ghats from Bombay southwards, and on the east from the Northern Circars southwards, the Andamans and Burma, in Martaban and Tenasserim ; also in Ceylon. The tree is fairly common in the moist evergreen forests of the Western Ghats, where it attains large dimensions ; on the Eastern Ghats it is found in the dry evergreen forests, often on laterite, as a comparatively small tree. In the Andamans it is common in the evergreen and semi-deciduous forests with *Dipterocarpus* spp., *Planchonia andamanica, Artocarpus Chaplasha, A. Lakoocha, Mesua ferrea, Hopea odorata, Terminalia bialata, T. Catappa, Lagerstroemia hypoleuca*, and other species. In its natural habitat the absolute

maximum shade temperature varies from 95° to 115° F., the absolute minimum from 50° to 62° F., and the normal rainfall from 30 to 150 in. or more.

The tree is largely cultivated in India and Burma for ornament and for the sake of its fragrant flowers, which are used for making garlands and for distilling into perfume.

FLOWERING AND FRUITING. The fragrant white star-shaped flowers appear from February to April, and the fruits ripen the following year from February to June or later. The fruit (Fig. 243, *a*) is an ovoid orange-yellow one-seeded berry, about 1 in. long. The seeds (Fig. 243, *b*) are elliptical or rhomboidal, compressed, 0·6–0·9 in. by 0·4–0·5 in., brown, smooth, shining, with a hard testa and a soft whitish albumen ; about 50–60 weigh 1 oz. The seeds do not retain their vitality long.

GERMINATION (Fig. 243, *c–g*). Epigeous. The hard testa splits in two, exposing the albumen ; the radicle emerges, the hypocotyl elongates by arching, and in straightening carries the cotyledons above ground. When the cotyledons expand the testa, or half of it, and the albumen often adhere for a time to one cotyledon before falling to the ground.

THE SEEDLING (Fig. 243).

Roots : primary root long, terete, tapering, wiry, flexuose : lateral roots moderate in number, fibrous, distributed down main root. *Hypocotyl* distinct from root, 1–2 in. long, terete, fusiform or tapering upwards, at first green and finely pubescent, becoming brown and woody. *Cotyledons* sub-sessile, 0·9–1·1 in. by 0·7–0·8 in., foliaceous, broadly ovate, entire, dark green, glabrous, coriaceous, persisting sometimes into the second season. *Stem* erect, terete or slightly compressed, wiry, green, young parts pubescent, older parts glabrous ; internodes 0·4–1 in. long. *Leaves* simple, alternate. Stipules minute, subulate. Petiole 0·1–0·15 in. long, flattened above : lamina 1·7–2·3 in. by 0·5–0·8 in., elliptical lanceolate, acute or acuminate, entire : young leaves sparsely pubescent, soon becoming glabrous, coriaceous, shining.

The growth of the seedling is slow, a maximum height of about 3 in. being ordinarily attained by the end of the first season. The seedlings are very sensitive to frost, which, however, is unknown in their natural habitat : they are capable of standing a considerable amount of shade.

SILVICULTURAL CHARACTERS. The tree is a shade-bearer, retaining a full crown under fairly dense shade. Gamble says it appears to reproduce well in shade and to remain small until an opportunity offers for removal of the cover, when it grows up at once. Judging from cultivated trees the growth is slow.

ARTIFICIAL REPRODUCTION. The best method of propagating the tree is to sow the seeds singly in baskets and plant these out bodily when the seedlings are large enough, that is, usually two years after sowing, in the rainy season.

2. **Mimusops hexandra,** Roxb. Syn. *M. indica*, A. DC. Vern. *Khirni*, Hind. ; *Ranjana, raini*, Mar. ; *Pala, palai*, Tam. ; *Palu*, Cingh.

A large handsome tree with a spreading crown and a straight massive bole ; the leaves are dark greyish green, shining, with an obtuse or emarginate apex, and are crowded at the ends of the branchlets. Bark rough, dark grey, crimson inside, and exuding drops of milky juice when cut. Wood red, very hard, heavy, tough, and durable, used for house-posts, turnery, oil-presses, and other purposes. The fruits are sweet and edible, and are largely collected

FIG. 243. *Mimusops Elengi*—SEEDLING × $\frac{5}{8}$

a—Fruits b—Seed c - g—Germination stages h, i—Early development of seedling

for food. Under unfavourable conditions, for example in very dry situations, the tree becomes stunted and even shrub-like.

DISTRIBUTION AND HABITAT. In dry forests of the Deccan, Circars, Orissa, and the Carnatic, extending north to the sandstone of the Pachmarhi hills and west to Khandesh and Guzerat. In the Central Provinces Haines [1] says it is common along sandy *nalas* in North and South Chanda, occurs in the Sirpur range, Raipur, and does well also in lime soils, being common on marl in the Sattara forest.

In the Indian Peninsula it is one of the principal trees of the dry evergreen forests of the Carnatic and surrounding country, especially on sandstone and laterite. In its natural habitat in India the absolute maximum shade temperature varies from 104° to 115° F., the absolute minimum from 32° to 58° F., and the normal rainfall from 25 to 60 in.

It is often cultivated for ornament and for the sake of its fruit.

In Ceylon the tree is of more importance than it is in India. Mr. A. F. Broun,[2] describing its occurrence and habit in that island, mentions that it is one of the most characteristic and important trees of the dry zone, occurring in the northern half and along the eastern and south-eastern fringes of the island at low elevations in situations having a rainfall of not much over 50 in. It does not occur in the wet zone. In favourable localities it attains a height of 100 ft. with a bole of 40 to 50 ft., but usually not more than 30 ft., and a girth up to 14 or 15 ft. The most favourable soil is a deep sandy loam, but it is found on almost pure sand, on gravel, clayey loam, and soil overlying limestone. On the poor soils of the arid zone it degenerates into a small tree. Among its chief companions in Ceylon are *Diospyros Ebenum*, *D. ovalifolia*, *Chloroxylon Swietenia*, *Berrya Ammonilla*, *Alseodaphne semecarpifolia*, and *Nephelium Longana*.

FLOWERING AND FRUITING. The white or pale yellow flowers appear from November to January and the fruits ripen from April to July. The fruit is an ovoid or ellipsoidal berry, 0·5–0·6 in. long, smooth and red when ripe, containing one reddish brown shining seed, rarely two seeds. Mr. Broun states that in Ceylon good seed-years, which are generally dry years, are very irregular.

SILVICULTURAL CHARACTERS AND NATURAL REPRODUCTION. Mr. Broun makes the following interesting observations regarding this tree in Ceylon: 'It is a curious fact that trees of the lower girth-classes are generally comparatively rare in high forests, but are found more abundantly in old *chenas* (regrowth after temporary cultivation). Enumeration survey figures . . . indicate that the tree does not reproduce itself easily under a dense leaf-canopy. The very appearance of the tree with its large crown, which it spreads out above its companions, shows that it likes to have light in large doses. It is therefore apparent that the seed fellings require to be made heavy. I have noticed that fellings in *palu* forests are not generally followed by the appearance of a seedling crop of that species, although seed-bearers were adjoining the gaps made. This is probably partly due to the great irregularity of the good seed-years, which are generally dry years, but I attribute it also to the following causes. The rainfall being slight, the seed exposed to the

[1] Central Provinces List

[2] Ind. Forester, xxvi (1900), p. 369.

scorching sun does not readily germinate, and if it does the tender seedling cannot stand the exposure, or it cannot force its roots through the tufts of dense *urry* grass which spring up on exposed patches. Moreover, the seed being edible and lying, as it does, in an exposed place, is soon carried away by animals; it is also removed by villagers in large quantities from the seed-bearers.

'As mentioned above, *palu* saplings are by no means uncommon in scrub forests; it follows that the young plant requires some low shelter, and this is obtained in high forest by sparing the undergrowth which protects the soil and spares the fruit. Perhaps the best method of carrying on seed fellings is to girdle the trees adjoining seed-bearers.'

Rate of growth. In Ceylon Mr. Broun estimates from sample plot statistics, which he admits to be scanty and tentative, that a girth of 6 ft. is attained in about 130 years. Owing to the compact and uniform nature of the wood the incremental rings are indistinguishable.

3. **Mimusops littoralis,** Kurz. Andaman bullet-wood. Vern. *Katpali*, Burm.; *Mohwa* (in the Andamans).

A large evergreen tree with leaves crowded towards the ends of the thick branchlets. Bark thin, smooth, blackish brown. Wood red, very hard, durable, used for bridge-construction and house-posts. Common along the coasts of the Andamans, Cocos, and Nicobar islands; also in upper Tenasserim (Kurz). In the Andamans this is a common tree in the mixed forests of the littoral fringe, in association with *Calophyllum Inophyllum*, *Afzelia bijuga*, *Thespesia populnea*, *Terminalia Catappa*, *Heritiera littoralis*, *Pongamia glabra*, and others. This type of forest occurs on raised beaches on deposits of sea-sand. *Mimusops littoralis* sometimes predominates, especially where the sand deposit is deep, forming at times almost a pure fringe. It often forms a protective belt against the force of the south-west monsoon, which it possesses good power of withstanding.

2. BASSIA, Linn.

Of the five Indian species of *Bassia* the best known and most widely distributed is *B. latifolia*, Roxb., while in southern India this species is replaced by *B. longifolia*, Linn., an important tree within its region. Both these trees are valuable on account of their flowers, the fleshy corollas of which are eaten or distilled into spirit, and their seeds, which yield oil. *B. butyracea*, Roxb., the seeds of which yield a vegetable butter, is a species met with in the sub-Himalayan tract and outer hills. The oily seeds of the trees of this genus have a high percentage of fertility when fresh, but lose their vitality if kept for any time.

Species 1. *B. latifolia*, Roxb.; 2. *B. longifolia*, Linn.; 3. *B. butyracea*, Roxb.

1. **Bassia latifolia,** Roxb., including *B. villosa*, Wall. Vern. *Mohwa*, Hind.; *Ippi*, Tel.; *Kat illipi*, Tam.

A large deciduous tree, usually with a short bole, spreading branches, and a large rounded crown. Bark grey, with vertical cracks.

This is one of the most important forest trees of India, its importance being due mainly to the fleshy corollas of its flowers, which are eaten raw or

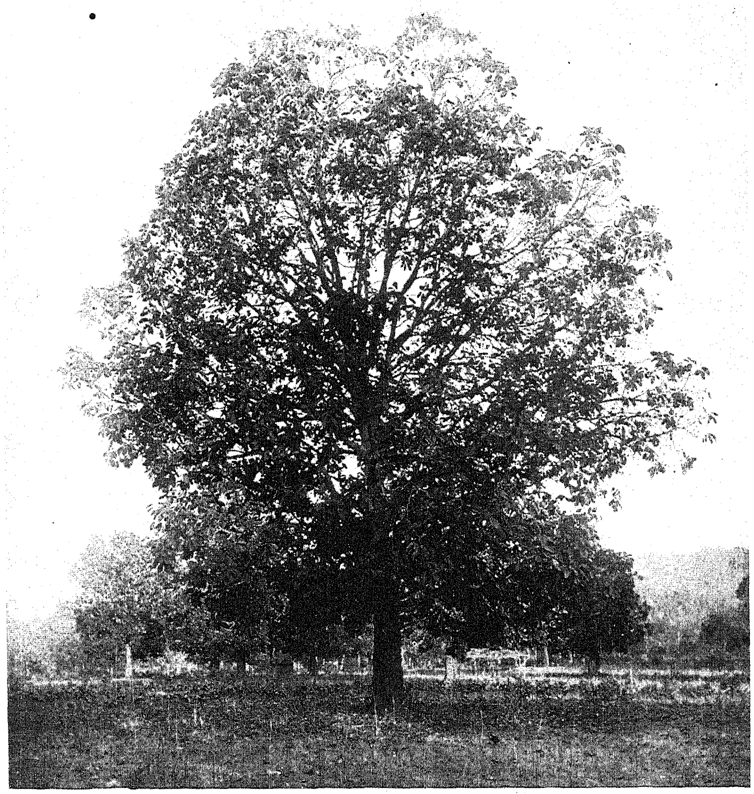

Fig. 244. *Bassia latifolia* tree, with others in background, remaining on former forest land cleared for cultivation, Singhbhum, Chota Nagpur.

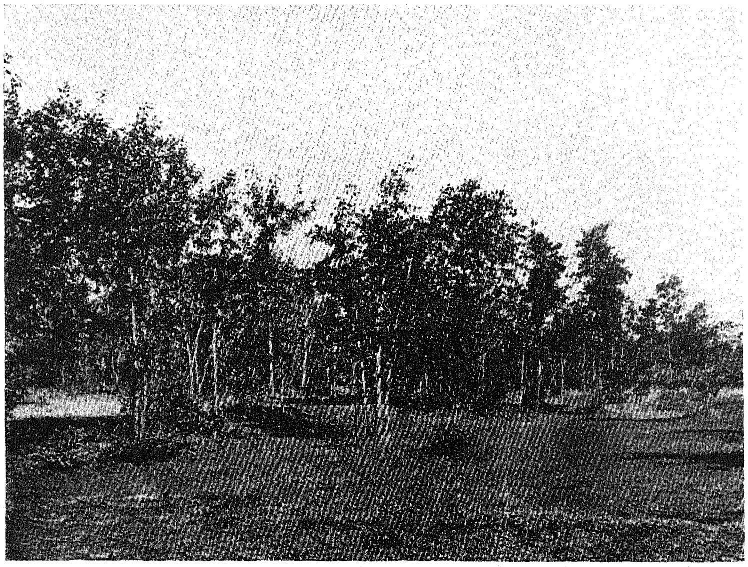

Fig. 245. *Diospyros burmanica*, regrowth from root-suckers and coppice-shoots on fields left unworked for four years, Burma.

cooked, or are dried, ground, and mixed with flour for making cakes, or are distilled into spirit. A thick white oil extracted from the seed is used by jungle tribes for cooking and burning, and is sold for the manufacture of margarine, soap, and glycerine. The wood is of good quality, but the tree is seldom felled, owing to the value of its flowers and fruits.

DISTRIBUTION AND HABITAT. Common in the deciduous forests of the Central Provinces, Bombay Presidency, northern parts of the Madras Presidency, Central India, Chota Nagpur, Orissa, and extending north to the sub-Himalayan tract in Oudh, Kumaun, and westward, though not common, to the Ravi. Doubtfully indigenous in Upper Burma. Not found in the southern parts of the Indian Peninsula. Much planted on the plains of northern India and in the Peninsula. The tree is a characteristic one in mixed deciduous forests, usually of a somewhat dry type, often growing on dry rocky or sandy soil, and thriving on the Deccan trap. It is common also in the drier types of sal forest in Chota Nagpur and the Central Provinces. When forest land is cleared for cultivation the *mohwa* trees are carefully preserved, and may be found scattered over cultivated lands long after the clearing has taken place (see Fig. 244).

In its natural habitat the absolute maximum shade temperature varies from 106° to 118° F., the absolute minimum from 30° to 46° F., and the normal rainfall from 30 to 75 in.

LEAF-SHEDDING, FLOWERING, AND FRUITING. The leaves fall gradually from February to April, and the new leaves appear about April or early May, with or shortly after the flowers. Fig. 244 shows a tree in March, partly bare of leaves. The new leaves are conspicuous from their coppery red colour. The brown flower-buds appear at the ends of the thick branchlets early in February, and the flowers open from the end of February to April. The corollas are 0·5–0·6 in. long, cream-coloured, fleshy, and sweet, and fall soon after opening. They are collected in large quantities off the ground, usually in places swept bare under the trees; they are also eagerly devoured by bears, deer, and other animals. The fruit, which is ovoid, fleshy, greenish, 1–2 in. long, 1- to 4-seeded, ripens from June to August, and falls at once to the ground. The seeds (Fig. 246, *a*) are 0·8–1·3 in. long by 0·5–0·7 in. broad, slightly compressed, ellipsoidal, light brown, smooth, shining, with a moderately hard testa; about 200 weigh 1 lb. on an average.

Fresh seed has a high percentage of fertility, but the seed quickly loses its vitality if kept, and is much subject to insect and fungus attacks. Specimens of a microlepidopterous insect whose larvae were found in large numbers destroying the insides of seeds have been named by Meyrick *Stathmopoda basiplectra*, sp. nov. Seeds attacked by fungi were examined by Dr. Butler, who detected two separate fungi, a *Diplodia*, probably parasitic, and a *Schizophyllum*, probably saprophytic after the seeds had lost their vitality. Affected seeds become rough and blistered, the surface often assuming a silvery colour, and the black pycnidia of the *Diplodia* appearing on the surface. The liability of the seed to attacks of insects and fungi is a matter of importance in so far as natural reproduction is concerned, for, as will be seen later, seed which becomes buried soon after falling germinates without being attacked.

The *mohwa* crop is of great importance to the jungle population, and

good flowering years are eagerly looked forward to. They do not occur every year, but, as far as records go, one to two good crops may be expected every three years. An otherwise promising crop is sometimes destroyed by hail before the flowers are developed. Trees are said to commence bearing crops of flowers and fruit when about ten years old. The yield of *mohwa* (corollas) per tree is said to be about a maund (82½ lb.) a year when fifteen years old, increasing to two maunds when in full bearing.

GERMINATION (Fig. 246, *b–f*). Hypogeous. Germination commences with the development of thick cotyledonary petioles, as in the case of many oaks. These petioles, which are not visible in the seed, reach a length of 0·6–1 in., and assist the radicle to make its way into the ground and the plumule to extricate itself from between the fleshy cotyledons, which are in close contact. The cotyledons remain underground, the testa breaking open as they swell.

THE SEEDLING (Fig. 246).

Roots: primary root long, thick, terete, tapering, light brown and delicate in early stages, soon becoming rough and woody: lateral roots at first few and short, afterwards longer and more numerous, fibrous, distributed down main root. *Hypocotyl* very short, subterranean, white turning green or reddish. *Cotyledons*: petiole 0·6–1 in. long, thick, fleshy, flattened, glabrous: lamina 1 in. by 0·6 in., thick, fleshy, oblong, outer surface convex, inner flat or slightly concave. *Stem* erect, terete, pubescent; first internode 1–2 in., subsequent internodes 0·5–1·3 in. long. *Leaves* simple, first pair opposite or sub-opposite, subsequent leaves alternate, first few leaves sometimes small and scale-like. Stipules 0·15 in. long, linear. Petiole 0·1–0·2 in. long, channelled above. Lamina 1–4 in. by 0·7–1·5 in., elliptical, oblong or ovate, apex and base acute or more rarely obtuse, entire, glabrous above, slightly pubescent beneath, especially on the veins, young leaves often coppery red.

The growth of the seedling is comparatively slow, and weeding and watering, though they stimulate development to some extent, appear to have a less marked effect on it than is the case with many other species. The following measurements of seedlings in experimental plots at Dehra Dun give some idea of the rate of growth under different conditions:

Bassia latifolia: rate of growth of seedlings, Dehra Dun.

Condition under which grown.	Height at end of season. 1st season.	2nd season.	3rd season.	4th season.
In nursery (weeded and watered)	Maximum 0 ft. 5 in.	Maximum 2 ft. 0 in.	..	..
Natural conditions (not weeded or watered) in full sunlight	(1) Maximum 0 ft. 4½ in. (2) 0 ft. 3 in.–0 ft. 7 in.	(1) Maximum 1 ft. 2 in. (2) Maximum 1 ft. 0 in.	(1) Maximum 2 ft. 0 in. ..	.. ..
Sowings, irrigated and weeded	0 ft. 1½ in.–0 ft. 5 in.	..	..	..
Sowings, irrigated but not weeded	0 ft. 1¾ in.–0 ft. 4¾ in.	..	..	..
Sowings, weeded but not irrigated	0 ft. 1½ in.–0 ft. 6 in.	..	0 ft. 6 in.–0 ft. 10 in.	Maximum 3 ft. 6 in.
Nursery-raised transplants (planted out in second rains)	..	Maximum 1 ft. 1 in.	Maximum 1 ft. 4 in.	..

Growth ceases from November to February, the new leaves appearing in March (Dehra Dun). Young plants are somewhat frost-tender.

SILVICULTURAL CHARACTERS. The tree has a large spreading root-system,

many of the roots being superficial. It is capable of thriving on poor dry ground, where, however, it is apt to suffer, sometimes severely, in times of abnormal drought. It is ordinarily frost-hardy, but in the severe frost of

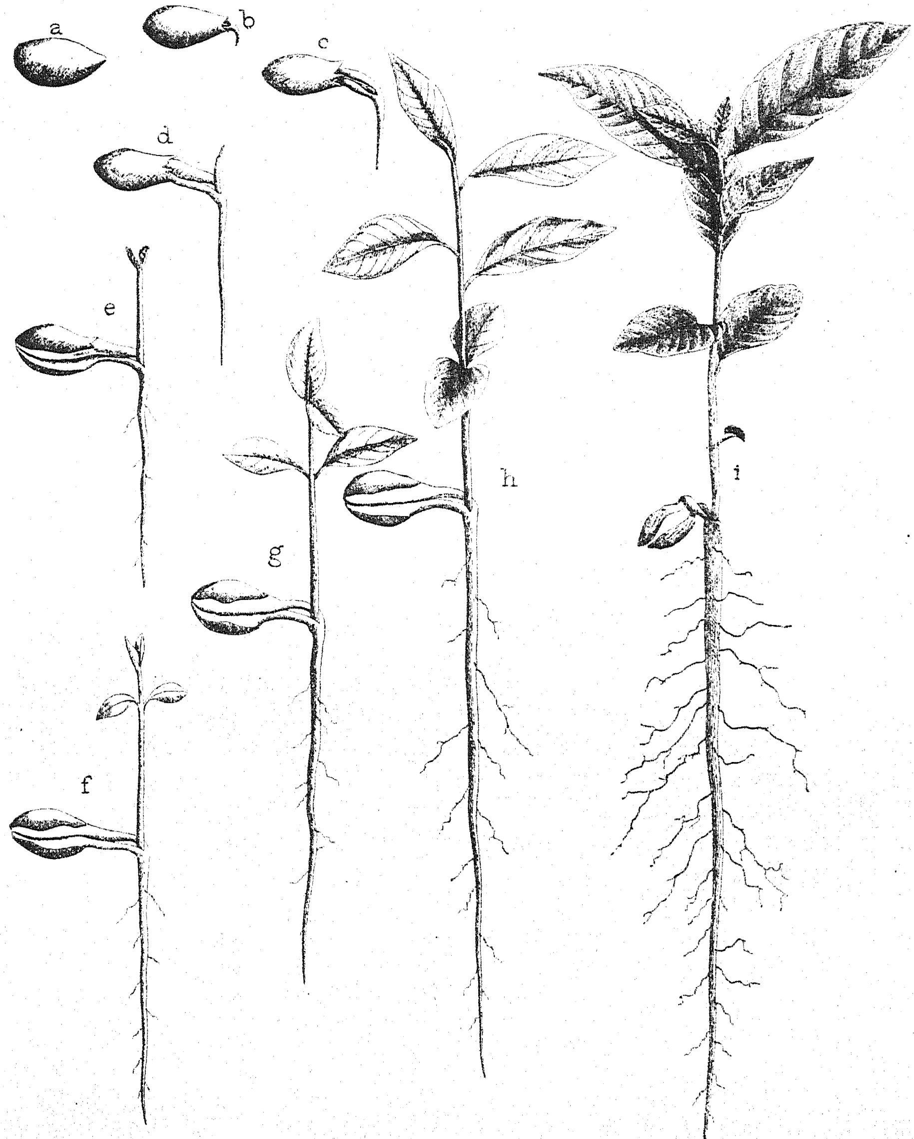

FIG. 246. *Bassia latifolia.* Seedling × $\frac{3}{8}$.
a, seed; *b–f*, germination stages; *g*, *h*, development of seedling during first season; *i*, seedling early in second season.

1905 it suffered to some extent in northern India. In its younger stages it is very liable to be browsed by deer and cattle. It is a strong light-demander, becoming readily suppressed under shade. It coppices fairly well if cut in the dry season, but not in the rains. In some localities the tree suffers greatly from the attacks of *Loranthus*; this is particularly the case in some parts of

the Central Provinces and Central India, where the trees are killed off in large numbers by this parasite, which itself dies after killing its host. Special measures are urgently called for to deal with this pest and to prevent its further spread. Systematic and repeated cutting of the parasite appears to be the only practical method of dealing with it ; *mohwa* lessees should be required to do this, and organized efforts should be instituted in the forest, in cultivated lands, and generally wherever the *Loranthus* makes its appearance.

NATURAL REPRODUCTION. The seed germinates early in the rainy season, soon after falling. For successful germination it is important that it should become covered with earth or débris, otherwise the seed is liable to fungus attacks, while the radicle is apt to dry up or to become eaten by insects if exposed. Natural seedlings are thus found chiefly in slight hollows into which earth is washed at the commencement of the rains. Their subsequent growth, which is comparatively slow, is favoured by the admission of abundant light.

ARTIFICIAL REPRODUCTION. The tree may be propagated either by direct sowing or by transplanting from the nursery. For forest purposes direct sowings in prepared lines or patches are preferable, as transplanting gives trouble and is attended with much risk owing to the long and rather delicate taproot developed by the seedling. In either case fresh seed should be sown about July–August, and care should be taken to cover it with earth to a depth of about half an inch.

For transplanting purposes it is preferable either to sow the seed direct in long pots or baskets, or to transplant the seedlings from nursery-beds into pots or baskets during the first rainy season a few weeks after germination. The plants may be put out in the forest early in the second rainy season. While they are in the nursery watering should be somewhat sparingly carried out, and the soil should be kept loose. Plantations should be protected from cattle and deer.

RATE OF GROWTH. Few reliable statistics are available regarding the rate of growth of this important tree. The following measurements are recorded in high forest sample plots :

Bassia latifolia : girth increment in high forest sample plots.

Province.	Forest division.	Locality.	Number of years under measurement.	Number of trees under measurement.	Girth classes.	Mean annual girth increment for period.
					ft.	in.
United Provinces	Gonda	Chandanpur and Sakra	2	5	$1\frac{1}{2}$–3	0·61
Central Provinces	Balaghat	Baihar and Raigarh	8	1	1–2	0·70
				3	2–3	0·23

As regards coppice, measurements made in 1911 in the Gonda district, United Provinces, in two coupes each two years old, showed an average height of 4·7 and 10 ft. as compared with 7·6 and 10 ft. for sal. Coppice-shoots one year old measured in Bhandara, Central Provinces, had an average height of 4·25 ft. as compared with 7·1 ft. for teak. Coppice measurements made in 1910 by Mr. C. M. McCrie in Gorakhpur, United Provinces, gave the following results for *Bassia latifolia* as compared with sal :

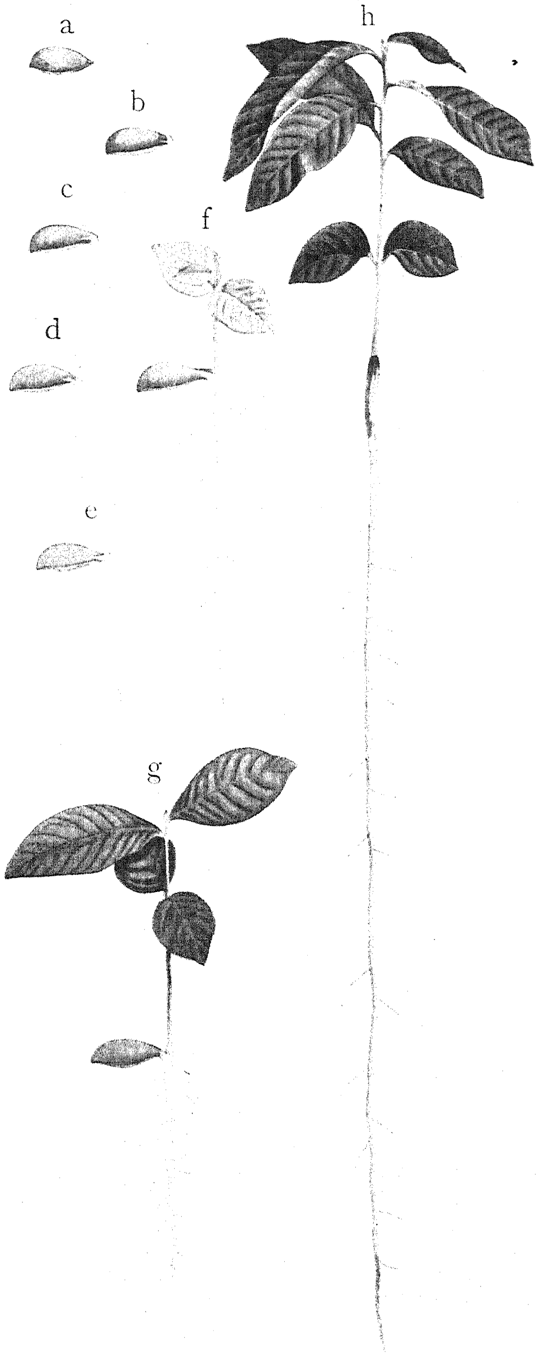

FIG. 247. *Bassia longifolia*—SEEDLING × $\frac{1}{4}$

a—Seed b - e—Germination stages f - h—Development of seedling to end of first season

Bassia latifolia : coppice measurements, Gorakhpur.

Age.	Mean height. Bassia.	Sal.	Mean girth. Bassia.	Sal.
years.	ft.	ft.	in.	in.
2	7	3	..	..
4	13	7	2·3	2
6	17·5	10·3	3·5	2·9
8	20	13	4·5	3·8
10	22	15·3	5·4	4·8
12	23·6	17·5	6·3	5·8
14	25	19·2	7·2	6·7
16	26·7	20·9	8·0	7·5

2. **Bassia longifolia,** Linn. Vern. *Ippi,* Kan. ; *Pedda ippa,* Tel. ; *Illupei,* Tam. ; *Mèzè,* Burm.

A large evergreen tree with a dense spreading crown and lanceolate leaves clustered at the ends of the branchlets. Bark yellowish grey to brown, red and milky inside. The wood is similar to that of *B. latifolia* : in Arakan it is used for ships' keels and is said to be very durable, resisting the attacks of the teredo. The flowers and seeds are used in the same way as those of *B. latifolia.* It is an excellent avenue tree.

Distribution and habitat. This tree replaces *B. latifolia* in southern India. It is indigenous chiefly in the monsoon forests of the Western Ghats from the Konkan southwards, where it is common along the banks of rivers and streams and in ravines : it extends into the Deccan. It is also common in many parts of southern India, where it is frequently cultivated as an avenue tree and for the sake of its flowers and fruits. In Arakan it is said to be indigenous in the Sandoway and Kyaukpyu districts : it is occasionally planted elsewhere in Burma. Although found wild most commonly in rather moist regions, it can be grown in comparatively dry localities.

Flowering and fruiting. The flowers, which have fleshy corollas like those of *B. latifolia,* appear in November–December in Bombay (Talbot), from February to May in Travancore (Bourdillon). The fruits ripen about June. The seeds (Fig. 247, *a*) are 1·2–1·6 in. long by 0·5–0·7 in. in diameter, compressed, light brown, smooth, shining, with a fairly thick and hard testa ; about 180–200 weigh 1 lb. The fertility of fresh seed is high, but the seeds do not retain their vitality long.

Germination (Fig. 247, *b–e*). Hypogeous, and similar to that of *B. latifolia.* It commences with the development of thick cotyledonary petioles, which, however, are not so long as those of *B. latifolia* ; these assist the radicle to make its way into the ground and the plumule to extricate itself from between the fleshy cotyledons. The cotyledons remain underground within the testa.

The seedling (Fig. 247).

Roots : primary root long, thick, terete, tapering, woody, pubescent when young : lateral roots moderate in number, fibrous, distributed down main root. *Hypocotyl* distinct from root, 1–1·5 in. long, thick, subterranean. *Cotyledons* : petiole 0·3–0·4 in. long, broad, thick, flattened, somewhat fleshy, bent to one side of stem : lamina 1–1·2 in. by 0·4–0·5 in., thick, fleshy, obliquely oblong, outer surface convex, inner flat. *Stem* erect, terete or slightly compressed, green or reddish, young parts pubescent, later becoming glabrous ;

internodes 0·4–3 in. long. *Leaves* simple, first pair opposite or sub-opposite, subsequent leaves alternate. Stipules 0·1–0·15 in. long, linear, pubescent. Petiole 0·1–0·2 in. long, pubescent. Lamina 1·6–4·5 in. by 1·3–2 in., elliptical or ovate, apex and base acute, or base sometimes obtuse in first pair, entire, pubescent or glabrescent; young leaves often coppery brown; lateral veins 9–16 pairs.

The growth of the seedling is moderate, a height of 6 in. to 1 ft. being attained in the first season and a height of about 1 to 2 ft. being ordinarily attained by the end of the second season. A long but somewhat fragile taproot is developed rapidly, the length being sometimes as much as 1 ft. within a month of germination, and 2 ft. by the end of the first season. Frost is unknown in the natural habitat of the tree; seedlings raised at Dehra Dun were found to be very frost-tender.

Artificial reproduction. In spite of the long fragile taproot the seedlings can be transplanted successfully with care during the first rainy season when about one month old. Fresh seed should be sown about June–July and well covered with earth. The most satisfactory method is to sow the seeds direct in long pots or baskets, or to prick them out into these from the seed-beds when about one month old, and to plant the seedlings out without disturbance of the root-system early in the second rainy season.

3. **Bassia butyracea,** Roxb. Vern. *Phalwara, phulwa, chiura,* Hind.

A large deciduous tree with leaves somewhat larger than those of *B. latifolia,* and crowded near the ends of the branches. Bark dark grey. The seeds furnish a white vegetable butter.

The tree occurs in the sub-Himalayan tract and outer Himalaya from the eastern Dun eastwards, ascending to 5,000 ft. In the hills it is found chiefly along the sides of ravines. It flowers in the cold season, and the fruits ripen in June–July; the seeds are 0·7–0·8 in. long. The growth is fast. A cross-section 3 ft. 5 in. in girth, without bark, in the silvicultural museum at Dehra Dun had 46 rings, giving a mean annual girth increment of 0·9 in. Gamble's specimens gave three to four rings per inch of radius, representing a mean annual girth increment of 1·57 to 2·1 in.

ORDER XXXVII. EBENACEAE

DIOSPYROS, Linn.

This genus, which contains nearly 50 Indian species, is of importance chiefly as containing the ebony-yielding trees. The true jet-black ebony of commerce is yielded by *D. Ebenum,* Koenig, which is of more importance in Ceylon than in India. The commonest Indian black ebony tree is *D. Melanoxylon,* Roxb. (including *D. tomentosa,* Roxb.), the heartwood of which, though not so jet black as the true ebony, is used to a considerable extent in India for carving and turning. Of variegated ebonies the best known are the calamander wood of Ceylon (*D. quaesita,* Thw.) and the marble-wood or zebra-wood of the Andamans (*D. Kurzii,* Hiern.).

Silviculturally this genus requires further study. Several species thrive in dry regions, for example *D. Melanoxylon, D. burmanica, D. Ebenum,*

and others. *D. Embryopteris* goes to the other extreme, thriving on moist and even marshy ground. The fruits are few-seeded berries; some of them are edible, and are readily devoured by fruit-bats, monkeys, and other animals, as well as by birds, particularly hornbills, and the seeds are scattered by their agency. As a rule the seeds have a high percentage of fertility. The seedlings develop long taproots at an early stage, often before any appreciable elongation of the shoot takes place. A curious creeping habit of the young taproot has been noticed in the case of *D. Melanoxylon*, *D. montana*, and *D. Chloroxylon* (see under these species); possibly this may also be the case in other species. The growth of the seedling is decidedly slow in all the species hitherto examined. A characteristic of certain species, notably *D. Melanoxylon* and *D. burmanica*, is the freedom with which root-suckers are produced; it is doubtful if any other Indian tree surpasses *D. Melanoxylon* in the profusion, hardiness, and tenacity of its sucker reproduction.

To this genus belongs the fruit-tree *D. Kaki*, Linn. f., the persimmon (Japanese *Kaki*, Burmese *Tayôk-tè*), which is much cultivated in China and Japan, and occurs wild in the Khasi hills and in Upper Burma. It has been tried in India, and has succeeded fairly well at Dehra Dun, where the fruit ripens towards the end of the rainy season. *D. Lotus*, Linn., vern. *amlok*, Punj., a native of western Asia, extending in the Himalayan region eastward to Kashmir and Hazara, is cultivated for its fruit in the Punjab and in the Mediterranean region: it is frequently cultivated round villages in Hazara.

Species 1. *D. Melanoxylon*, Roxb. (including *D. tomentosa*, Roxb.); 2. *D. Embryopteris*, Pers.; 3. *D. Kurzii*, Hiern.; 4. *D. burmanica*, Kurz; 5. *D. Ebenum*, Koenig; 6. *D. Chloroxylon*, Roxb.; 7. *D. montana*, Roxb. (including *D. cordifolia*, Roxb.); 8. *D. ehretioides*, Wall.

1. **Diospyros Melanoxylon**, Roxb., including *D. tomentosa*, Roxb. Vern. *Tendu*, Hind.; *Balai*, Kan.; *Tumki*, Tel.

In his *Forest Flora of North-West and Central India* Brandis unites these two, but in his *Indian Trees* he separates them, while expressing doubt as to their being distinct species. Gamble, in his *Manual of Indian Timbers*, mentions that it is very difficult to distinguish them either in the field or in the herbarium. Haines, in his *List of Trees, Shrubs, &c., of the Southern Circle, Central Provinces*, notes that both varieties occur mixed up and appear to be often indistinguishable, but that in the region dealt with *D. tomentosa* is perhaps more eastern in its distribution: see also his *Forest Flora of Chota Nagpur*. The main botanical distinction consists in *D. Melanoxylon* having leaves narrower than *D. tomentosa*, with base and apex often acute and secondary nerves raised, while *D. tomentosa* usually has rounded or obtuse leaves and secondary nerves impressed above. So far as the two have been studied silviculturally, their characters appear to be identical, and unless further study should reveal any radical differences they may be united from a silvicultural point of view.

A small to moderate-sized, occasionally large tree, with leaves opposite, sub-opposite, or alternate, coriaceous, and varying much in size and form. Bark greyish black, exfoliating in regular rectangular scales. Wood hard, reddish brown, with an irregular black heartwood sometimes streaked with purple or brown. The wood is used for building, shafts, shoulder-poles, and other purposes, and is carved into walking-sticks, picture-frames, and fancy articles; when burnt it emits showers of sparks, and is therefore not a safe

fuel. Silviculturally the tree is of importance in clothing dry poor ground, and is interesting owing to its wonderful hardiness in surviving maltreatment.

DISTRIBUTION AND HABITAT. The distribution of *D. Melanoxylon* is stated to be the Indian Peninsula generally, extending northward to Bihar, and that of *D. tomentosa* the sub-Himalayan tract from the Ravi to Nepal, eastern Rajputana, the Central Provinces and Berar, Bihar and Orissa, and the Northern Circars. Both are common in the Central Provinces, and Haines says that the latter is the commoner form in Chota Nagpur, where it is one of the commonest trees throughout the forests. Considering the two forms as one species, this is one of the most characteristic trees of the dry mixed deciduous forests throughout India. It is locally common also in sal forest, often replacing the sal where the ground becomes too poor to support the latter. In the Peninsula it appears to reach its best development on metamorphic rocks.

In its natural habitat the absolute maximum shade temperature varies from 105° to 119° F., the absolute minimum from 30° to 55° F., and the normal rainfall from 20 to 60 in.

LEAF-SHEDDING, FLOWERING, AND FRUITING. The tree is leafless for a short time in the hot season or is frequently never quite leafless. The flowers appear from April to June, and the fruits ripen from April to June the following year. The fruit is a globose to ovoid berry, 1–1·5 in. in diameter, smooth and yellowish when ripe, with 3–8 seeds embedded in a sweet yellow edible pulp. The seeds (Fig. 248, *a*) are oblong, compressed, 0·5–0·8 in. long, brown, shining, with a wrinkled testa and ruminate albumen. About 25 to 40 weigh 1 oz. Fresh seeds have a high percentage of fertility; different samples of seed tested at Dehra Dun after being stored for a year had a fertility of 10, 55, and 60 per cent. respectively. The fruits are readily eaten by fruit-bats and by birds, notably hornbills, which may often be seen in quantity among the trees at the time the fruits are ripening; the seed is spread by their agency.

GERMINATION (Fig. 248, *b–f*). Epigeous. The radicle emerges from one end of the seed and descends rapidly, forming a taproot of some length before the elongation of the hypocotyl is completed. The hypocotyl elongates by arching, and in straightening raises above ground the cotyledons enclosed in the testa and albumen. The cotyledons are caducous, and either they become detached before extricating themselves from the testa and fall to the ground still enclosed in it, or more usually they extricate themselves, the testa falling to the ground, but they fall off not long after.

THE SEEDLING (Fig. 248).

Roots: primary root long, thick, at first fleshy, afterwards woody, black, tomentose, often bent or swollen in upper part near ground-level: lateral roots short, fibrous, distributed down the main root. *Hypocotyl* distinct from root, 1·2–1·6 in. long, slightly compressed or terete, tapering upwards, minutely tomentose, at first smooth and pink with a pale grey or pale yellow base, afterwards rough and reddish brown to nearly black. *Cotyledons* sessile, 0·7–0·8 in. by 0·25–0·3 in., foliaceous, oblong lanceolate, apex acute or rounded, entire, glabrous, delicate, white, pale pink or pale green, caducous, venation reticulate. *Stem* erect, slightly compressed or terete, woody, tomentose; internodes 0·1–0·7 in. long. *Leaves* simple, exstipulate, first pair or sometimes two pairs opposite, subsequent leaves alternate or sub-opposite. Petiole about 0·1 in. long, tomentose. Lamina 1–2 in. by 0·6–1·2 in., elliptical, ovate

FIG. 248. *Diospyros Melanoxylon*—SEEDLING × $\frac{3}{8}$

a– Seed b - f—Germination stages g - j—Development of seedling to end of first season

or obovate, apex acute, obtuse or rounded, base rounded or slightly cordate, entire, coriaceous, glabrescent or sparsely pubescent with yellowish hairs, principal veins of lower surface pubescent; older leaves dark-green, younger leaves dull reddish green; lateral veins 5 to 10 pairs, in *D. tomentosa* impressed on the upper surface, in *D. Melanoxylon* somewhat variable, but for the most part not impressed.

Note.—This description applies to the seedling both of *D. Melanoxylon* and of *D. tomentosa*.

The main development of the seedling during the first year or two is underground; a long taproot is quickly formed, and may attain a length of 1 ft. or more in a few weeks, and a length of 2 ft. or more with a diameter of nearly ½ in. by the end of the second season. Meanwhile the growth above ground is slow, a maximum height of 3 or 4 in. being attained by the end of the first season; during the second season the growth is not much faster except under favourable conditions, when a height of 1–2 ft. may be reached by the end of the season. Under unfavourable conditions dying back may take place, particularly where drought is severe, the stem of the young plant dying down while the root system develops, and a new stem being produced the following year. The season's growth ceases about November (northern India); some seedlings are leafless by February–March, but others are never quite leafless, the old leaves continuing to fall throughout March. New growth begins in March or April. The seedlings stand a considerable amount of shade, persisting under it for some time. They are hardy against frost and drought, but not against excessive damp, and tend to rot in heavy damp weed-growth. They have great power of struggling through grass, but their development suffers, while more vigorous growth is promoted if the ground is kept clear of weeds and periodically loosened.

Silvicultural characters. In the seedling and young pole stage the tree stands moderate shade, but later it requires more light. It is decidedly frost-hardy, and in the abnormal frost of 1905 in northern India it resisted the frost more successfully than almost any other species. It is also drought-resistant; in the abnormal drought of 1907 and 1908 in the forests of Oudh it proved to be conspicuously hardy (*D. tomentosa*), but in the severe drought of 1899–1900 in the Indian Peninsula it was affected to some extent, though sucker reproduction is said to have escaped injury (*D. Melanoxylon*). Young plants and suckers are immune from damage by browsing; in heavily grazed sal forest in Oudh an undergrowth of this species may be found in places where the ground has been grazed bare, while in over-grazed forests in the Peninsula the prevalence of a stunted growth of *Diospyros* is a familiar sight, the development of the tree being probably hindered by the trampling and hardening of the soil and not by browsing.

The tree coppices moderately well, but the coppice-shoots grow slowly; it pollards better, though the growth of the pollard-shoots is also slow. Coppice experiments in North Chanda, Central Provinces, showed that after April the coppicing power is very poor, the percentage of stools which coppiced successfully in different months being (1) April 100, (2) May 30, (3) August nil. The extensive production of root-suckers, however, is one of the most characteristic features of this tree. Its hardiness and immunity from damage by grazing assist it to establish itself in quantity by this means, and on cleared forest

land masses of sucker reproduction persist for many years after other species have disappeared, and they are difficult to eradicate on land required for cultivation. Similarly on abandoned cultivation sucker growth springs up readily, and if left alone may result in pure crops of *Diospyros*.

NATURAL REPRODUCTION. As already mentioned, the seeds are spread by fruit-bats and by birds, notably hornbills ; seedlings may sometimes be found in the forks of trees or in other places above the ground, the seed having been conveyed there by their agency. Under natural conditions, germination begins early in the rainy season and continues during that season ; some seed may remain dormant until the second rainy season. Germination is greatly favoured if the seed becomes covered with earth, as in this case the radicle is less liable to destruction by insects, or, if exposed to the sun, by drought. Nevertheless the young taproot is very hardy, and under shade or under the protection of grass it may creep for some distance along the surface of the ground until it is able to penetrate the soil ; this is a common habit in natural seedlings. The profusion and tenacity of sucker reproduction is, however, in itself sufficient to ensure the survival and increase of this species even without the aid of seedling reproduction, which is itself often plentiful.

ARTIFICIAL REPRODUCTION. Experiments at Dehra Dun have shown that transplanting from the nursery is attended with much risk owing to the large size of the taproot ; this applies both to seedlings transplanted entire and to those transplanted with pruned stem and root. Probably the most successful method, if planting has to be resorted to, would be to sow the seeds in long narrow baskets and to plant these out intact in the second rains. Sowing should be carried out about April–May, care being taken to cover the seeds with earth. Direct sowing is usually preferable to transplanting, the best method being to sow in lines and to keep the lines weeded during the first two or three years. Line sowings with the aid of field crops have been carried out in the Amraoti forest division, Berar.[1]

RATE OF GROWTH. The few sample plot measurements available indicate that the rate of growth is slow ; these are as follows :

Diospyros Melanoxylon and *D. tomentosa* : rate of growth in high forest sample plots.

Province.	Forest division.	Locality.	Number of years under measurement.	Number of trees under measurement.	Girth classes.	Mean annual girth increment for period.
					ft.	in.
United Provinces	S. Kheri	Kishanpur	9	1	1–2	0·23
Central Provinces	Balaghat	Raigarh and Baihar	8	2	2–3	0·20

A tree felled in West Kurnool, Madras, had 216 rings for a girth of 6 ft., representing a mean annual girth increment of 0·33 in.[2]

Coppice growth is also slow. Measurements made in 1911 in two coppice coupes each two years old in the Gonda district, United Provinces, gave an average height of 4 and 4·8 ft. as compared with 7·6 and 10 ft. for sal ; in

[1] Ind. Forester, xxxvii (1911), p. 8.

[2] Working Plan for the Gundlabrahmeswaram Range, West Kurnool, H. F. A. Wood, 1912.

either coupe the average number of shoots per stool was 1·4, and the rate of growth of this species was slower than that of any other species present. Measurements in 1912–13 in coppice coupes one year old in Bhandara, Central Provinces, showed an average height of 5·1 ft., as against 7·1 ft. for teak, 3·9 ft. for *Buchanania latifolia*, and 3·8 ft. for *Soymida febrifuga*.

Measurements made in 1910 by Mr. C. M. McCrie in coppice coupes in the Gorakhpur district, United Provinces, gave the following results :

Diospyros tomentosa : rate of growth of coppice, Gorakhpur.

Age. years.	Mean height. ft.	Mean girth. in.	Age. years.	Mean height. ft.	Mean girth. in.
2	4·8	1·8	10	9·1	3·9
4	6·8	2·8	12	9·3	4·1
6	7·9	3·3	14	9·3	4·2
8	8·7	3·6	16	9·3	4·3

2. **Diospyros Embryopteris,** Pers. Vern. *Gáb, kala tendu,* Hind. ; *Timburi,* Mar. ; *Kusharta,* Kan. ; *Niti tumiki,* Tel.

A moderate-sized, much-branched, handsome evergreen tree with a short bole and a dense rounded crown of dark green foliage with shining coriaceous leaves. Bark smooth, dark greenish grey. The fruits are rich in tannin, and the unripe fruits contain a viscid pulp used as gum in bookbinding and for paying the seams of boats. The tree is often planted for ornament in gardens ; it is not a timber tree.

Distribution and habitat. The sub-Himalayan tract from the Jumna to the Tista, Chota Nagpur, in many parts of the Indian Peninsula, and in Martaban and Tenasserim. The tree frequents moist and even swampy ground along streams and in shady ravines, where it is sometimes more or less gregarious. In the Dehra Dun valley it is characteristic of swamp forests, in association with *Putranjiva Roxburghii, Ficus glomerata, Eugenia Jambolana, Pterospermum acerifolium, Carallia lucida, Trewia nudiflora, Bischoffia javanica,* and a few other species. In the Sundarbans it is found on old village sites in the interior.

Flowering and fruiting. In northern India the creamy white fragrant flowers appear from March to May along with the young leaves, which are bright crimson. The fruits begin to ripen about May in the following year, but may be found on the tree for a few months later ; they are more or less globose, 1·5–2 in. in diameter, covered with a red velvety tomentum (Fig. 249, *a*) ; they contain about 5–8 seeds in a glutinous pulp. The seeds (Fig. 249, *b*) are 0·6–0·8 in. by 0·4–0·45 in., compressed, with a fairly thick testa ; about 350–400 weigh 1 lb. The fertility of fresh seed is high, but so far as tests at Dehra Dun show the seed does not retain its vitality for a year. The fruits are eaten by fruit-bats and monkeys, and the seeds are distributed by their agency.

Germination (Fig. 249, *c–g*). Epigeous. The radicle emerges from one end of the seed and descends rapidly, forming a black taproot of some length before the elongation of the hypocotyl is completed. The hypocotyl elongates by arching, and in straightening raises above ground the cotyledons enclosed in the testa and albumen. The cotyledons are caducous, and are usually left

wholly or partially enclosed in the seed-coat, falling with it, or sometimes they extricate themselves, the testa falling to the ground, but they in their turn soon fall, leaving the pointed plumule, from which the first pair of foliage leaves soon expands.

THE SEEDLING (Fig. 249).

Roots: primary root long, thick, terete, tapering, black, at first fleshy, afterwards woody, minutely tomentose; lateral roots moderate in number, short, fibrous, chiefly in apical part of main root. *Hypocotyl* distinct from root, lower portion 0·5–0·7 in. in length, swollen, grey or light greenish brown, upper portion, 1·5–2·2 in. in length, compressed, pink or green turning dark greenish brown, glabrescent or finely pubescent. *Cotyledons*: petiole 0·1 in. long, channelled above; lamina 1–1·3 in. by 0·4–0·5 in., foliaceous, oblong lanceolate, entire, glabrous, pale pink, caducous, apices folded into the albumen. *Stem* erect, compressed, pubescent, dark greenish brown, young parts red; internodes 0·2–0·7 in. long. *Leaves* simple, exstipulate, first one or two pairs opposite or sub-opposite, subsequent leaves alternate or sub-opposite. Petiole 0·1–0·2 in. long, flattened above, minutely pubescent. Lamina 1·5–3 in. by 0·4–0·7 in., oblong lanceolate, entire, dark green, smooth, shining, coriaceous, glabrous above, pubescent on midrib beneath, young leaves red.

The growth of the seedling is very slow, averaging only a few inches a year for the first three years. Seedlings raised at Dehra Dun attained the following maximum heights by the end of the first five seasons: (1) 6 in., (2) 8 in., (3) 10 in., (4) 2 ft. 9 in., (5) 3 ft. 2 in. A long taproot is developed early, and may attain a length of 9 in. within a month of germination; its subsequent growth is slower, a length of about 18 in. being ordinarily attained by the end of the second season.

In their earlier stages the seedlings are subject to the attacks of insects, while birds, squirrels, and hares bite off the young shoots. Seedlings are sensitive to frost and drought; they require shade for their best development, and are apt to die off if exposed to a hot sun. They also require plentiful moisture in the soil.

SILVICULTURAL CHARACTERS. The tree is a shade-bearer; in the natural state young plants develop freely under a fairly heavy canopy. It thrives with abundance of moisture in the soil, and along streams and in swampy ground it is sometimes found growing with its roots submerged in running water; very moist ground, however, is not essential for its growth, since it is found wild, and is often cultivated, on ordinary loam, where it thrives, provided the soil is not too dry.

NATURAL REPRODUCTION. The seed is frequently spread by animals, particularly monkeys and fruit-bats, and possibly also by birds; groups of seedlings have been observed in the forks of trees several feet above ground, from seed carried by fruit-bats and passed out in their excreta.

The fruits themselves fall to the ground from about June or July onwards, and soon dry up or rot, the seeds being exposed; provided the latter become buried within a reasonable time, or are lying in a moist shady place, germination takes place during the rainy season, but seeds lying exposed in the open usually fail to germinate.

ARTIFICIAL REPRODUCTION. Seedlings can be raised in the nursery and transplanted successfully provided care is taken not to injure the long taproot.

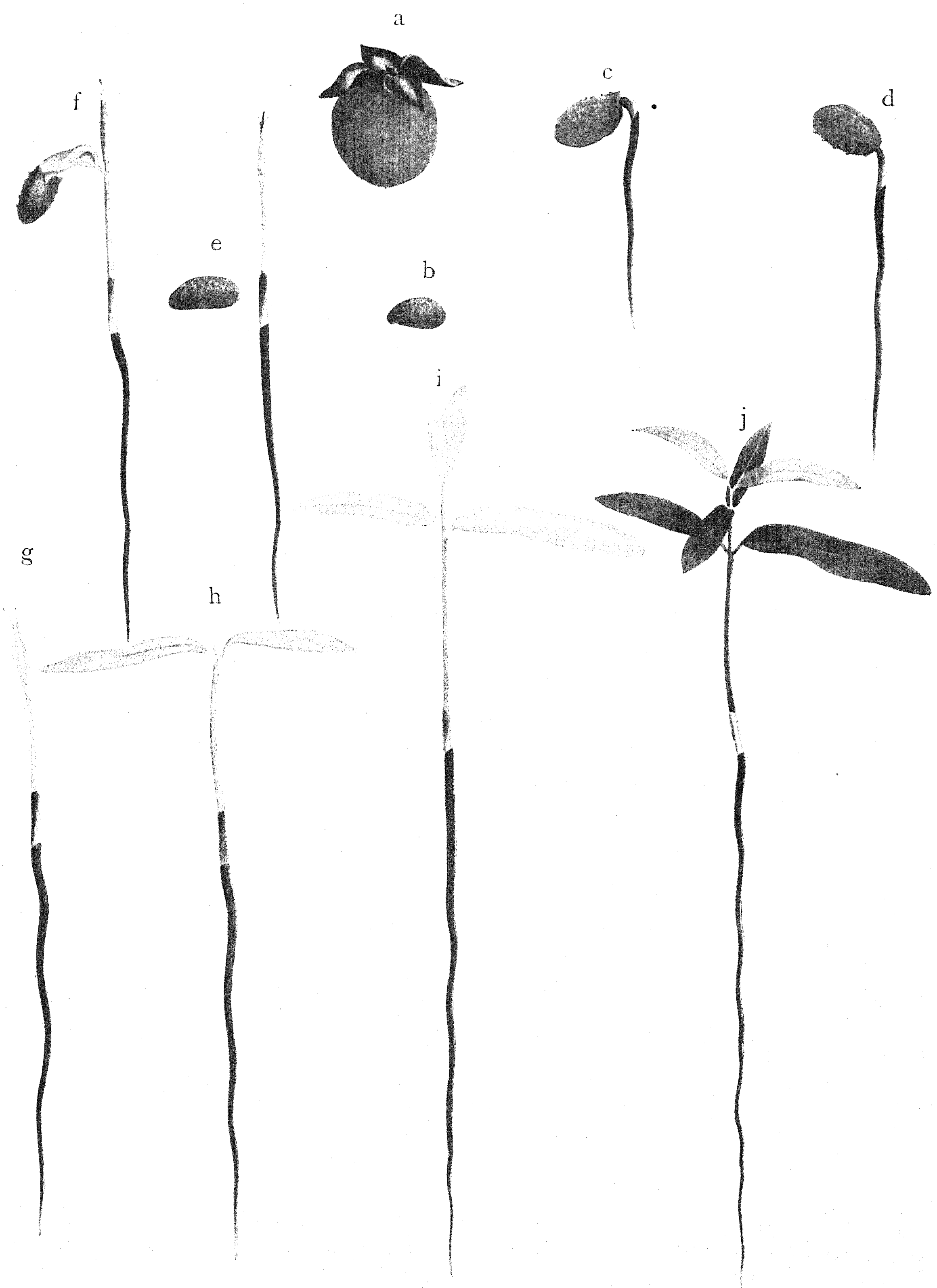

FIG. 249. *Diospyros Embryopteris*—SEEDLING × $\frac{1}{2}$

a—Fruit b—Seed c - g—Germination stages h - j—Development of seedling to end of first season

Fresh seed should be sown in the seed-beds about July, the seeds being placed about 4 in. apart in drills 9 in. apart. The soil should be well worked up before sowing, and subsequently prevented from caking, and the beds should be shaded and well watered in dry weather. The seedlings usually appear in two to three weeks after sowing. Transplanting may be done either in the first or in the second rainy season ; dry situations exposed to the sun should be avoided, the seedlings being planted if possible under moderate shade, preferably from the side. Watering may be necessary for a time after transplanting. If the trees are grown for their fruit, wide spacing, say 20 ft. by 20 ft. or even more, is necessary owing to the spreading nature of the crowns.

RATE OF GROWTH. The rate of growth is moderate. A cross-section in the silvicultural museum at Dehra Dun had 70 rings for a girth of 3 ft. 3 in., or a mean annual girth increment of 0·56 in. Brandis gives 7–8 rings per inch of radius, representing a mean annual girth increment of 0·78–0·9 in.

3. **Diospyros Kurzii,** Hiern. Andaman marble-wood or zebra-wood. Vern. *Pecha-da*, And. ; *Kala lakri*, Hind. (in Andamans) ; *Thitkya*, Burm. (in Andamans).

An evergreen tree with thin smooth grey bark, ordinarily attaining a height of 40 to 50 ft. with a clear bole of 15 to 20 ft. and a girth up to 5 ft. ; occasionally it reaches larger dimensions. The wood, which is known on the London market, is a valuable and very handsome variegated ebony with alternating streaks of black and grey ; the out-turn of variegated wood from the log is, however, comparatively small.

The tree is found throughout the Andamans, and occurs also in the Nicobars and Coco Islands. It is found scattered in semi-deciduous and evergreen forests, usually on low-lying and undulating ground, along with padauk (*Pterocarpus dalbergioides*) and its associates. Its silviculture has not been studied in detail.

4. **Diospyros burmanica,** Kurz. Vern. *Tè*, Burm.

A small to moderate-sized deciduous tree with rigid branches. Bark rough, blackish. This tree is common in Burma in *indaing* forest of a dry type, usually on laterite, along with *Dipterocarpus tuberculatus*, *Shorea obtusa*, *Pentacme suavis*, *Buchanania latifolia*, and other trees characteristic of this type of forest, and also in the dry open mixed forests of the dry zone of Burma. The flowers appear in March–April, and the fruits ripen in December–January ; they are 1–1·5 in. in diameter, sweet and edible when ripe. The tree produces root-suckers freely, and often springs up gregariously on abandoned cultivation by means of suckers from roots left in the ground (see Fig. 245).

5. **Diospyros Ebenum,** Koenig. Ebony. Vern. *Karunkáli*, Tam. ; *Tuki*, *nalluti*, Tel. ; *Kaluwara*, Cingh.

A large evergreen tree with a dense crown and thick dark coriaceous leaves. Bark dark grey, rather rough, with longitudinal cracks. Mr. A. F. Broun [1] says that in Ceylon it attains a girth up to 14 ft. ; in India it is of comparatively small size. The heartwood furnishes the true ebony of commerce, a jet-black, very hard, close-grained wood, used for turnery, carving, piano-keys, and fine ornamental work of various kinds. The tree is of great commercial importance in Ceylon, whence the wood is regularly exported to

[1] Ind. Forester, xxv (1899), p. 275.

Europe and elsewhere; in India, however, the trees are neither large nor common enough to be of any great importance commercially.

Distribution and habitat. Sparsely scattered in the forests of the Deccan and Carnatic, chiefly in Kurnool and Cuddapah, scarcer farther south. Bourdillon says that in Travancore it has been found only in the Anjinaud valley in the north, but it may also occur on the slopes above Puliyan and near Panagudi. It is a tree of the dry regions, and occurs chiefly in dry evergreen forests.

In Ceylon, according to Mr. Broun, it is most abundant in the dry zone, and the richer forests are all in the northern half of the island, especially in the eastern portion of the North Central Province; it is also well represented in the Northern and North-Western Provinces. Outside the dry zone it occurs in the intermediate zone, and in the south of the island it penetrates even into the moist zone. The best ebony is found on rocky well-drained soil, usually on sandy loam with a good subsoil drainage, but at times on soil with a fair proportion of clay; it is frequently found near watercourses which are dry during part of the year, but never on swampy soil. It does not grow pure, but is found scattered in mixture with many other species, including *Chloroxylon Swietenia*, *Mimusops hexandra*, *Nephelium Longana*, *Gleniea zeylanica*, *Vitex altissima*, *Albizzia odoratissima*, *Berrya Ammonilla* (on moister soils), and other species of *Diospyros*.

Flowering and fruiting. In Ceylon the flowers appear about March, but the flowering season seems to be rather irregular; the fruits usually ripen before the north-east monsoon, that is, about September–October, but the tree is said occasionally to seed twice a year. Good seed-years are somewhat irregular, and the seed is liable to the attacks of weevils (Broun).

Silvicultural characters. The seedlings endure a fair amount of shade, but after they have established themselves the admission of light directly overhead is beneficial. Mr. Broun considers that it is best not to admit too much light until the maximum height is reached, when space should be given for the development of the crown.

Rate of growth. The rate of growth is slow. Mr. Broun gives for Ceylon the following average figures, which, however, he admits to be only tentative:

Girth. ft. in.	Corresponding age. years.
1 6	25
3 0	75
4 6	135
6 0	200

6. **Diospyros Chloroxylon,** Roxb. Vern. *Ninai, nensi,* Mar.; *Ullingi,* Tel.

A large shrub or small tree, often spinescent. Bark rough, dark grey, with small rectangular corky scales. Wood yellowish grey. This is a useful fuel plant, and yields good fodder; the fruits are edible. It is found in many parts of central and southern India, extending north to Orissa, Chanda, and Nasik. It is common in dry deciduous forests; Gamble says it is common in the dry evergreen forests of Cuddapah, Kurnool, North Arcot, and Chingleput, preferring laterite and sandstone hills, and is a useful fuel plant; Haines says it is common on cotton soil in North and South Chanda.

The flowers appear in June–July, and the fruits ripen from January to April. The fruit is globose, smooth, shining, 0·3 in. in diameter, with 2–3 seeds. The seeds have a high percentage of fertility, and tests at Dehra Dun gave a fertility of 80 per cent. with seeds kept for one year. Experimental plots at Dehra Dun showed that under natural conditions germination starts early in the rainy season, and that, as in the case of *D. Melanoxylon* and *D. montana*, if the seed is not buried, the young taproot may creep along the surface of the ground for some time in its efforts to penetrate the soil. In this case if exposed to the sun the seedling soon perishes, but under shade it may remain alive and vigorous; seedlings with two well developed foliage leaves have been observed with their taproots still creeping along the surface of the ground and developing lateral rootlets, although not yet established in the soil. The seedlings are capable of standing a considerable amount of shade and of persisting under grass; they ordinarily reach a height of 4–6 in. in the first season. The tree produces root-suckers.

7. **Diospyros montana,** Roxb., incl. *D. cordifolia*, Roxb. Vern. *Bistendu*, Hind.; *Tembhurni*, Mar.; *Vakkanai*, Tam.; *Chôk*, Burm.

A small to moderate-sized, very variable, deciduous tree, often spinescent. Nowhere very common, but widely distributed in deciduous forests throughout the greater part of India and in Burma (var. *cordifolia* only). The wood does not furnish any black heartwood. The flowers appear from March to June, and the fruits ripen from December to February (northern India), but the fruiting season appears to vary; Bourdillon (Travancore) and Talbot (Bombay) say the rainy season. On three occasions I have received fresh seeds from the Central Provinces in June–July. The fruit is globose or ovoid, 0·7–1·2 in. in diameter, greenish yellow, turning black. The seeds are 0·6–1·1 in. by 0·4–0·5 in., brown, compressed; the percentage of fertility is high.

Under natural conditions the seed germinates early in the rainy season, and if it lies unburied the taproot may crawl along the surface of the ground for some time before it succeeds in penetrating the soil, as in the case of *D. Melanoxylon* and *D. Chloroxylon*. Under these conditions, if exposed to the sun, the germinating seedlings are liable to perish, but under shade they persist for some time until the taproot eventually establishes itself. Grass and weed-growth also act as an efficient protection during germination. The seedlings are capable of standing fairly dense shade. Their growth is slow.

8. **Diospyros ehretioides,** Wall. Vern. *Aukchinsa*, Burm.

A large deciduous tree with spreading branches and large leaves up to 1 ft. or more in length. The wood, which is grey with darker streaks, sometimes handsomely mottled, is not much used. This is a familiar tree in the mixed deciduous forests of Burma, both in the upper and in the lower mixed types, though perhaps commoner in the latter. It is somewhat shade-bearing, its spreading crown being often conspicuous below an upper story. The fruits ripen in the cold season and are eaten by hornbills, as the Burmese name implies.

ORDER XXXVIII. OLEACEAE

Genera 1. Fraxinus, Linn.; 2. Olea, Linn.; 3. Nyctanthes, Linn.; 4. Schrebera, Roxb.

1. FRAXINUS, Linn.

Brandis (*Indian Trees*) enumerates five Indian species: (1) *F. floribunda*, Wall., flowers with petals, appearing after the leaves; Afghanistan, trans-Indus, Himalaya, Khasi hills and Shan hills. (2) *F. Griffithii*, Clarke, flowers with petals, appearing after the leaves; Mishmi hills. (3) *F. excelsior*, Linn. (including *F. Hookeri*, Wenzig), flowers without petals, appearing before the leaves, leaflets two to four pairs, base entire, upper part slightly serrate; western Himalaya from the Ravi drainage westwards. (4) *F. oxyphylla*, M. Bieb., similar to (3) but leaflets one to four pairs, coarsely serrate; Baluchistan, Afghanistan. (5) *F. xanthoxyloides*, Wall., syn. *F. Moorcroftiana*, Brandis, a shrub or small tree with very variable leaves, occurring in dry situations in the western Himalaya, Afghanistan, and Baluchistan.

Parker (*Forest Flora for the Punjab*), distinguishing between *F. floribunda*, Wall., and *F. micrantha*, Lingelsh.—a very similar species except that the flowers have no petals—gives (1) *F. floribunda*, Wall., Himalaya, Nepal, Assam; all the western Himalayan species he has seen belong to *F. micrantha* and not to *F. floribunda*. (2) *F. micrantha*, Lingelsh., Himalaya 6,000–7,000 ft., Kumaun to Bashahr and probably farther west; he has, however, seen only one Punjab specimen.

Species 1. *F. floribunda*, Wall.; 2. *F. excelsior*, Linn.; 3. *F. xanthoxyloides*, Wall.

1. **Fraxinus floribunda,** Wall. Indian ash. Vern. *Sum*, *angu*, W. Him.

A large deciduous tree with opposite imparipinnate leaves; leaflets usually seven to nine, all with petiolules except the upper pair, which are sub-sessile. Branchlets purple, compressed, glabrous, with white lenticels. Bark grey, smooth on young poles, rough with deep longitudinal furrows on older trees. Wood pinkish white, moderately hard, tough, used for oars, shoulder-poles, &c.

It is probable that many specimens termed *F. floribunda* in the forest are in reality *F. micrantha* (see introduction to this genus).

The Indian ash is found in the Himalayan region from Sikkim westwards at 5,000–9,000 ft., in the Khasi hills, and the Shan hills of Upper Burma at 4,000 ft. It is occasionally cultivated in the Himalaya at suitable elevations. In the wild state the tree is by no means abundant, its distribution being somewhat local; it is confined as a rule to rich moist soils and shady situations. Mr. Fernandez [1] says that in the Naini Tal district it occurs generally in the neighbourhood of limestone rocks, and that it seeds profusely and reproduces fairly well on loose soil free from weeds.

The tree is leafless in the winter. The flowers appear in April–May and the fruits ripen in September–October. The seed lies dormant in the ground for a whole year, and transplanting from the nursery is therefore better than direct sowing. Seed may be sown in the nursery in the autumn of ripening

[1] Naini Tal Working Plan.

or in the following spring; in either case it germinates in the spring about seventeen or twelve months later as the case may be. Transplanting is preferably done in the winter with seedlings kept about two seasons in the nursery. During the first season the growth of the seedling is comparatively slow, but during the second season it is usually faster, a height of 2 ft. being attainable by the end of the season under favourable conditions, while by the end of the third season a height of 3–5 ft. is ordinarily attained. The treatment of the seed usually followed in Europe in the case of *F. excelsior* (see below) may prove suitable for this species.

The growth is slow to moderate: Gamble's specimens gave an average of 13 rings per inch of radius, representing a mean annual girth increment of 0·48 in. Wallich gives 8 rings, or a mean annual girth increment of 0·78 in.

2. **Fraxinus excelsior,** Linn. European ash. Vern. *Súm*, Punjab.

A large straight-stemmed tree. Bark (India) light grey, smooth in young trees, becoming rough with deep longitudinal furrows in old trees. Wood whitish, moderately hard, tough and elastic, used for oars, shafts, tool-handles, and many other purposes. In the European ash there are nine to fifteen leaflets; the Indian representative has usually five, rarely seven leaflets, and this together with other distinctions led Wenzig to regard it as a distinct species (*F. Hookeri*, Wenzig).

Fraxinus excelsior occurs wild in the western Himalaya at 7,000–10,000 ft. elevation in Hazara, Kashmir, and Chamba. Its distribution is very local; it is confined to moist, deep, fertile soil, often in the neighbourhood of streams, and attains a height of 80–90 ft. and a girth of 8 ft. and over. There are some good specimens in the upper Siran valley in Hazara, on deep, moist, fertile loam obtained from the decomposition of mica schist; here the tree grows on the sides of moist ravines, often in the neighbourhood of running water, the surrounding forest consisting of spruce, silver fir, blue pine, and deodar, as well as horse-chestnut, maple, walnut, and other broad-leaved species. Fig. 250 shows a large tree in this locality. Natural reproduction springs up chiefly on newly exposed clean ground on the sides of moist ravines, often among boulders.

The artificial cultivation of this ash deserves more attention. It has been planted with success as low as 4,000 ft., and appears to grow better at lower than at higher elevations. For planting purposes, however, care is necessary always to select deep, moist, fertile soil, preferably on the sides of ravines or near mountain streams.

Based on European experience, its characters and requirements may be briefly indicated. The tree is a light-demander, but stands some shade in youth. It avoids sandy soil, thriving best on deep, moist, fertile loam, and in Europe is found most commonly on low ground near rivers. It has a well-developed root-system, and is wind-firm. It is sensitive to drought and to frost. It coppices and pollards well, and reproduces to some extent by suckers; stools, however, do not live very long. In Europe the seed ripens in October and falls during the winter, germinating in the second spring: it retains its vitality for two or three years. Before sowing it is usual to bury the seed in sand from the time it ripens until the second spring, when it is sown as late as possible to avoid the risk of late frosts. In nurseries the seedlings are

pricked out in the spring the year after sowing, and are ready for planting out one or two years later.

The ash is treated as coppice, coppice-with-standards, on the pollard system, or as high forest, in which case it should be underplanted with a shade-bearer. The height-growth is fairly rapid, but the tree does not attain a great age or a very large diameter.

3. **Fraxinus xanthoxyloides,** Wall. Syn. *F. Moorcroftiana*, Brandis. Vern. *Sanjal, hanúz, anga*, W. Him.

A large shrub or small tree with branchlets compressed and minutely and densely pubescent. Bark grey, smooth, dark and cracked when old. Wood hard, used for tool-handles, walking-sticks, and fuel. Indigenous in the western Himalaya from Kashmir to Kumaun at 3,000–9,000 ft., trans-Indus, Afghanistan, and Baluchistan; locally plentiful and often gregarious on dry slopes, chiefly in the inner Himalayan valleys. In Hazara it occurs on dry hill-sides in scrub forest in the Kagan valley, chiefly between 4,500 and 6,000 ft., associated at the lower elevations with *Acacia modesta*, *Olea cuspidata*, *Berberis* spp., and *Punica Granatum*, and in places with *Quercus Ilex*. Fig. 251 shows the rocky ground on which it is often found. The tree is much lopped for fodder. It is an important species in the Baluchistan forests. The flowers appear March–April and the fruit ripens July–August. Adverse weather conditions sometimes prevent the ripening of the seed. The growth is slow: Brandis gives 20 rings per inch of radius, representing a mean annual girth increment of 0·31 in. The following measurements of coppice-shoots in the Hazar-Ganj forest are recorded in the Baluchistan Forest Reports for 1914–15 and 1915–16:

Fraxinus xanthoxyloides: coppice measurements, Hazar-Ganj forest, Baluchistan, 1914–16.

Age.	Height. 1914–15.	Height. 1915–16.	Age.	Height. 1914–15.	Height. 1915–16.
years.	ft.	ft.	years.	ft.	ft.
1	1–3	..	6	4–10	..
2	2–4	2–4	7	6–12	6–12
3	2–6	2–5	8	8–13	8–13
4	2–4	6–8	9	6–14	10–14
5	..	6–9	10	..	10–15

2. OLEA, Linn.

Species 1. *O. cuspidata*, Wall.; 2. *O. glandulifera*, Wall.; 3. *O. dioica*, Roxb.; 4. *O. europaea*, Linn.

1. **Olea cuspidata,** Wall. Syn. *O. ferruginea*, Royle. Indian olive, wild olive. Vern. *Kao, kahu*, W. Him.; *Zaitún*, Pushtu. (Fig. 252.)

A moderate-sized unarmed evergreen tree with small coriaceous leaves, dark green above, reddish brown beneath. Bark grey, thin, smooth, exfoliating in narrow strips. Wood brown, very hard, close grained, used for tool-handles, turnery, combs, &c.; an excellent fuel. This species yields very little oil from the fruit kernels, but it makes a suitable stock on which to graft the cultivated olive, *O. europaea*, Linn., to which it is closely allied. It attains a height of 30 to 40 ft. and a girth of 6 ft. or more.

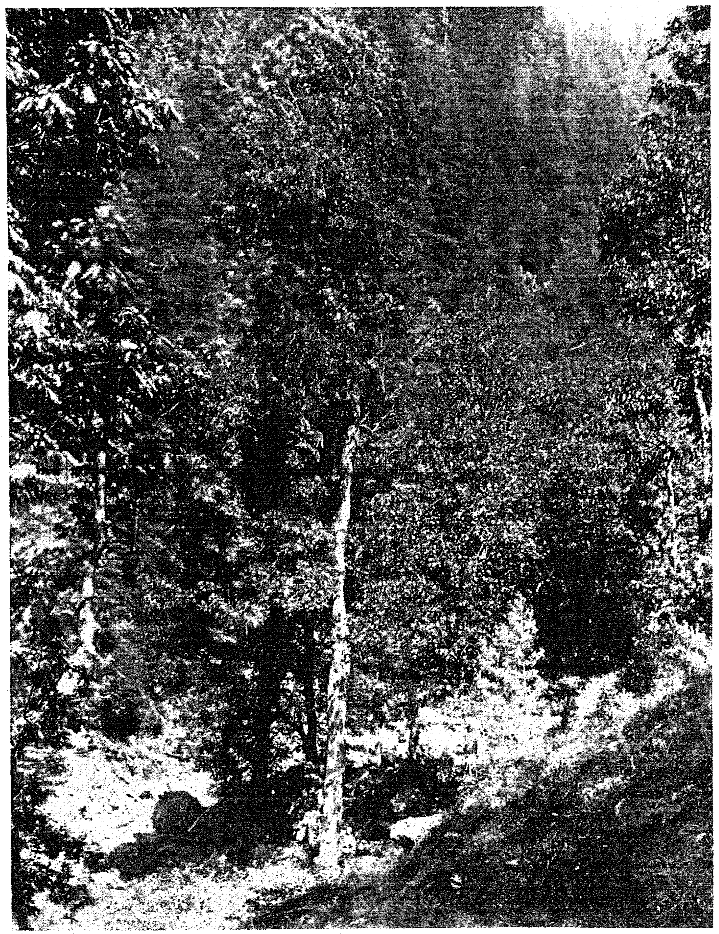

Fig. 250. *Fraxinus excelsior* (with man at base), girth 8 ft. 1 in., Upper Siran valley, Hazara.

Fig. 251. *Fraxinus xanthoxyloides*, Kagan valley, Hazara.

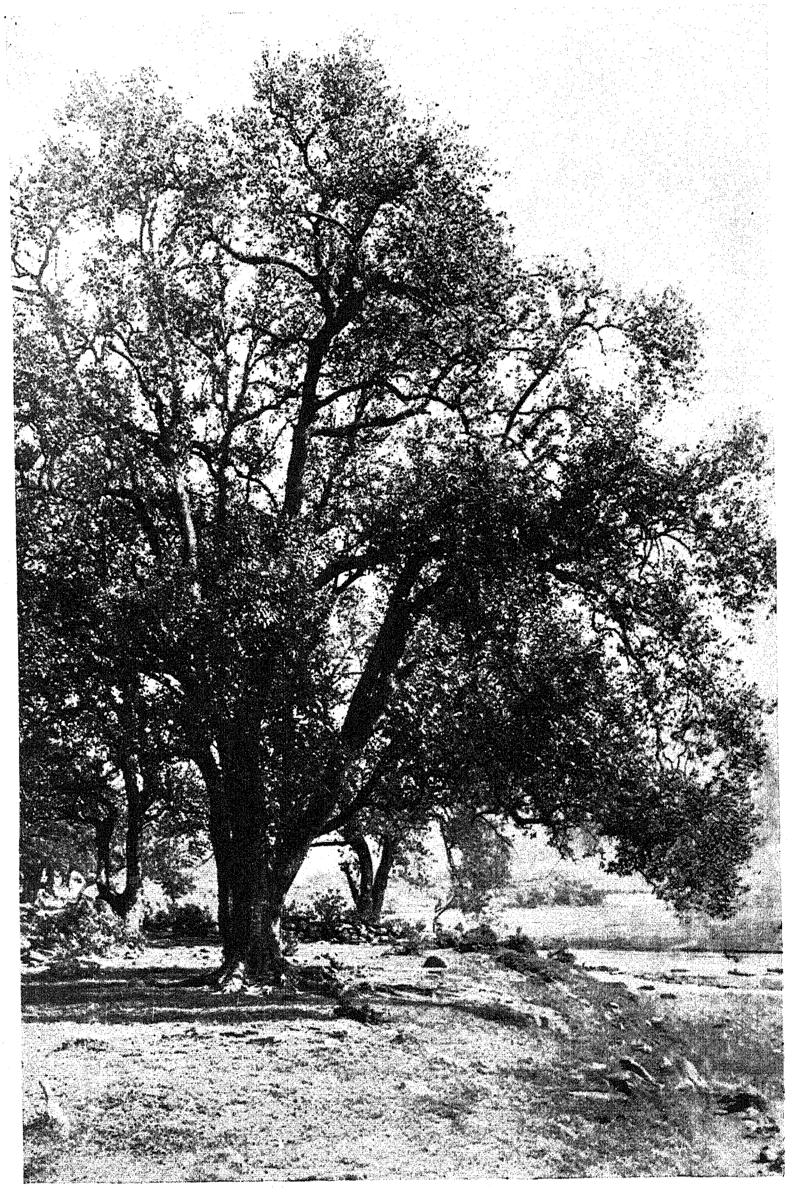

Fig. 252. *Olea cuspidata*, Hazara.

Distribution and habitat. Indigenous in the western Himalaya, ascending to 6,000 ft., from the Jumna westward, the Suliman and Salt Ranges, hills to the west of Sind, Afghanistan, and Baluchistan. In the western Himalaya it is somewhat local, occurring chiefly along the outer hills and in the dry inner valleys. In the trans-Indus country, along the eastern flank of the Suliman and other ranges, it is often abundant. In the Salt Range it grows equally well on limestone, sandstone, shale, and marl. It is usually more or less gregarious, and is very common on hilly ground, often associated with *Dodonaea viscosa*, *Acacia modesta*, *A. Catechu*, *Carissa spinarum*, *Reptonia buxifolia*, and *Pistacia integerrima*; in the *Pinus longifolia* forests it often occurs on rocky ground on hot aspects. In the Kalachitta range of hills in the Rawalpindi district it is abundant on limestone, favouring the valleys and the northern slopes up to 1,500–2,000 ft., above which altitude it is gradually replaced by *Dodonaea*: on hot exposed situations with shallow soil it is less plentiful, giving way to *Acacia modesta*. Except in a few places at the foot of this range it does not extend into the plains. In Hazara it is common on the limestone hills of the Khanpur range at 2,500 to 5,000 ft., associated with *Acacia modesta*, *Punica Granatum*, *Berberis Lycium*, *Pinus longifolia*, and other species; in the Kagan valley it is found on hot hill-sides at 3,500–5,500 ft., often with *Fraxinus xanthoxyloides*. It is often planted in gardens in the plains of northern India. The tracts in which the tree grows wild are characterized by great heat and long periods of drought in the hot season, with a considerable degree of cold in the winter; the rainfall for the most part varies from 15 to 30 in.

Leaf-shedding, flowering, and fruiting. The leaves are shed in January–February and the new leaves appear before the old ones all fall. The white flowers appear from March to September, according to locality and elevation. The fruit, which ripens from September to December, is a black ovoid drupe about 0·3–0·5 in. long with a bony endocarp.

The seedling. The growth of the seedling is very slow, an average height of only about 3 in. per annum being the usual rate of growth during the first three years. A long taproot is developed at an early stage. The seedling is sensitive to drought, and under natural conditions requires shade and moderately good soil for its establishment.

Silvicultural characters. The tree is a shade-bearer. It is browsed by camels and goats; browsed plants usually assume a dense shrubby form with small leaves, from the centre of which a few long shoots with normal leaves appear, which, if allowed, grow up into trees. Deer and wild sheep (oorial), where present, also do damage by browsing, especially to coppice-shoots. The tree is often lopped for fodder. It coppices well if cut in the dry season, and produces root-suckers. Experiments carried out in the Punjab in 1912 and 1913 showed that from August to October inclusive coppicing was a failure, while from January to June inclusive it was very successful; coppicing in July gave moderately good results, while the results of fellings in November and December were not conclusive when the observations were recorded.[1]

Natural reproduction. Mr. B. O. Coventry[2] has recorded some

[1] Punjab Forest Conference Proceedings, 1913 and 1914.

[2] Ind. Forester, xli (1915), p. 395.

observations on the natural reproduction of the wild olive. Germination appears to take place about February, and the essential conditions for successful reproduction are shade during youth and sufficient depth of fertile humus soil. Mr. Coventry contrasts the absence of reproduction in the Kalachitta and Khairimurat ranges of the Rawalpindi forest division, where the soil is shallow, exposed, and denuded, with the satisfactory reproduction observable in parts of the Salt Range, where owing to more effective cover and more favourable soil conditions natural seedlings are to be found in some quantity; these seedlings are always found under the shade of bushes or trees and in pockets of good humus soil, never in the open or on shallow denuded soil. The presence of olive trees in the former tract is accounted for by the fact that these must have sprung up when the ground was well covered with shrubs and trees and the soil had not become denuded, and the perpetuation of the species has been effected by suckers and not by seedling reproduction.

ARTIFICIAL REPRODUCTION. The tree may be grown from seed sown towards the end of the cold season in light porous mould, either in pots or in raised nursery-beds; the seedlings should be kept shaded and regularly watered. The young plants may be planted out during the rainy season of the following year, or, if irrigation is possible, in April. Direct sowings in blanks always fail, but seed sown in fairly good soil under the shade of bushes may have a reasonable chance of success. The tree can be grown successfully from cuttings, pieces of mature wood about $\frac{1}{2}$–1 in. in diameter being used: it can also be raised successfully by transplanting root-suckers.

RATE OF GROWTH. The growth is slow. The annual rings are not distinct, but can sometimes be distinguished with approximate accuracy: by their aid and by measurements of coppice-shoots, it is estimated in the Kalachitta working plan that coppice attains a girth of 15 in. in about thirty years, and this period has been adopted as the rotation for coppice fellings. Coppice-shoots six years old in the Dartian reserved forest, Khanpur range, Hazara, reached a height of 11 ft. and a girth of 4 in. at the base. Generally speaking, it may be said that the more vigorous coppice-shoots grow for some years at the rate of about 2 ft. per annum.

2. **Olea glandulifera,** Wall. Vern. *Gulili, gair, galdu,* W. Him.

A moderate-sized tree with a shady, broad, rounded crown and a short bole. Wood hard, durable. Indigenous in the outer Himalaya, up to 6,000 ft., usually in shady ravines and along rivers and streams; Mothronwala swamp, Dehra Dun. Gamble's specimens showed 12 to 33 rings per inch of radius, or a mean annual girth increment of 0·19 to 0·52 in., which is slow. Brandis mentions a section of a tree forty-three years old, grown in the Botanic Gardens, Calcutta, which had 43 rings on a radius of 10 in., giving a mean annual girth increment of 1·48 in., which shows that the growth under favourable conditions may be fast.

3. **Olea dioica,** Roxb. Vern. *Karamba,* Mar.

A moderate-sized tree of the eastern Himalaya, Duars, Assam, Chittagong, Western Ghats, southwards to Travancore, in moist forests, both evergreen and deciduous. Bourdillon says that in deciduous forest in Travancore it does not attain more than 50 ft. in height, but in evergreen forest it reaches a height of 100 ft. and a diameter of $2\frac{1}{2}$ ft. He gives the rate of growth as 5 rings per

inch of radius, representing a mean annual girth increment of 1·26 in. The wood is of good quality, but is apparently not used. Fl. January to March; fr. April to June, S. India (Bourdillon).

4. **Olea europaea,** Linn. European olive, common olive.

A tree closely allied to *O. cuspidata*, but the leaves are grey above and white beneath, the inflorescence is denser, the fruit larger, and the branchlets in the ungrafted plant are spinescent. The olive is indigenous in Syria and is largely cultivated in the Mediterranean region and in certain valleys in the Alps. According to Professor Raoul Blanchard[1] the distribution of the olive in the French Alps depends little on soil, latitude, or altitude, the deciding factor being exposure, for the tree must have shelter from north, north-west, and north-east winds, and will not tolerate any wind-swept situation; the most favourable aspects in that region are southerly to easterly.

The cultivation of the olive has been attempted from time to time in India, and within recent years experimental cultivation has been carried on with some success in the Punjab by grafting on stocks of *O. cuspidata*. Systematic experiments were started in 1910–11 at Sakesar in the Shahpur district and Khairimurat in the Rawalpindi district, and some of the grafted trees commenced bearing fruit after four years. Experiments have also been carried out in Kashmir and in Baluchistan. In 1910 about 200 olive plants obtained from southern France were planted in Baluchistan, and these fruited in 1916. Budding was carried out on stocks of wild olive (*O. cuspidata*), the latter being cut down to produce coppice-shoots, which were large enough for budding when three years old. It was found that the best time to bud is about September.

3. NYCTANTHES, Linn.

Nyctanthes Arbor-tristis, Linn. Vern. *Har, harsingar, karasli, siharu,* Hind.; *Harsing,* Kan.; *Parijtak,* Mar.; *Krishti,* Tel.; *Seikpalu,* Burm.

A large shrub or small tree with drooping quadrangular branches and scabrous leaves. Bark grey or greenish white, rough. Common in the sub-Himalayan tract, in the Siwalik hills and outer Himalaya up to 5,000 ft., from the Chenab to Nepal, Chota Nagpur, Central India, Central Provinces, southward to the Godavari, Burma (rare). Often cultivated for its fragrant flowers. Within its region this tree, often nothing more than a shrub, is important from its capacity for clothing dry steep hill-sides and rocky ground, where it is often gregarious, forming almost the only vegetation and serving to fix unstable or denuded slopes, where it spreads quickly. It sends out long stout lateral roots from which are produced bushy suckers in abundance: it also reproduces readily from seed. It stands a moderate amount of shade, and is often found as an undergrowth in dry deciduous forests. It is not readily browsed, even by goats, and thus succeeds in establishing itself even where there is grazing. It coppices readily, and gives good fuel. It is leafless in April–May. The fragrant flowers, with orange-red corolla-tubes and white spreading lobes, appear from August to October, and the capsules ripen from November to February.

[1] La Géographie, October and November 1910.

4. SCHREBERA, Roxb.

Schrebera swietenioides, Roxb. Vern. *Mokha, ghant*, Hind.; *Mogalinga*, Tam.; *Makkam, mokkalapa*, Tel.; *Thitswelwè*, Burm.

A moderate-sized deciduous tree with grey branchlets thickened at the nodes and opposite imparipinnate leaves. Bark grey, thin, scaly. Wood hard, close grained, used for house-posts, turning, &c.

The tree is found in rather dry mixed deciduous forests often on hilly ground, in the sub-Himalayan tract from the Ramganga river eastwards, Chota Nagpur, Central India, Rajputana, the Central Provinces, and the Indian Peninsula generally; Burma, in dry mixed forests. It is not a gregarious tree, but is found scattered in greater or less abundance in mixture with other species.

The tree is leafless from February–March till April–May. The terminal cymose panicles of yellowish brown flowers appear with the young leaves from April to June, and the fruits ripen during the following cold season. The tree is easily recognized from its characteristic fruit, a pear-shaped, two-valved, two-celled, woody capsule about 2–2·5 in. long, with two to four large angular seeds in each cell.

The tree stands a slight amount of shade. In the abnormal drought of 1899 and 1900 in the Indian Peninsula it was only slightly affected, but it is somewhat sensitive to frost. It produces root-suckers.

Little is known regarding the rate of growth: a cross-section 2 ft. 1 in. in girth in the silvicultural museum at Dehra Dun had 31 rings, giving a mean annual girth increment of 0·8 in.

ORDER XXXIX. SALVADORACEAE

SALVADORA, Linn.

Species 1. *S. oleoides*, Dcne.; 2. *S. persica*, Linn.

1. **Salvadora oleoides,** Dcne. Vern. *Wán, ván, jál*, Punjab; *Kabbar, jhár*, Sind; *Pilu*, Mar.

A shrub or small tree with drooping branches, evergreen or nearly so. Wood sometimes used for building, agricultural implements, &c.; a poor fuel. The sweet fruit is eaten, often dried. The tree is a useful one for clothing desert tracts: it gives a dense shade which is welcomed by cattle in the heat of the day. This is a common species in the arid desert tracts of the Punjab and Sind, and occurs to some extent in Rajputana. In the Jaipur State it is common. It is gregarious, and is frequently associated with *Capparis aphylla*, *Prosopis spicigera*, *Tamarix articulata*, and sometimes with *Salvadora persica*. In the trans-Indus hills it ascends to 3,000 ft., and in the Salt Range to 2,400 ft. (Brandis). It seems to thrive where the rainfall is below 25 in., becoming scarcer where it is higher. It is capable of thriving on saline soils, where, however, it is stunted.

It coppices fairly well, and regenerates freely by root-suckers and to some extent by natural layers. A dense, almost impenetrable growth is often formed by a parent stem surrounded by a ring of root-suckers, while seedlings also spring up under its shade. The new leaves appear about April. The small

greenish white flowers appear in March–April and the fruits ripen about June : the fruit is a yellow berry 0·2 in. in diameter. The seeds are spread by birds, and seedlings may be found under bushes of *Capparis aphyllæ* or sometimes epiphytically on *Tamarix* and other trees. The tree suffers little from grazing except where it is very heavy ; it is often lopped for camel and goat fodder. It suffers considerably from frost.

2. **Salvadora persica,** Linn. Syn. *S. indica*, Wight ; *S. Wightiana*, Planch. Tooth-brush tree, mustard tree (of Scripture). Vern. *Kabbar*, *pilu*, Sind ; *Jál*, *jhál*, Rajputana ; *Khakhin*, Mar. ; *Ghunia*, Tel. ; *Opa*, Tam.

A small evergreen tree with drooping branches, sometimes attaining 30 to 40 ft. in height, with a short, often fluted stem. The leaves and fruits are pungent. Wood soft, white, little used. A tree of the dry and arid regions of India, with a wider distribution than the last : Baluchistan, Sind, trans-Indus, Punjab, Rajputana, Ganges valley round Delhi and Agra, the Circars, Guzerat, the Konkan, North Kanara, and the Deccan. It is often found on saline soil, and in the Peninsula on black cotton soil. In North Kanara it grows on the sea-coast above high-water mark in thickets with *Clerodendron inerme*, *Zizyphus Oenoplia*, *Z. Jujuba*, and other species (Talbot). In the Thana district it is found along tidal creeks with *Aegiceras* and *Avicennia* (Ryan). It grows readily from seed and coppices well (Brandis). In the Punjab the seed ripens in June. For planting purposes seedlings ought usually to be kept in the nursery for three years. Coppice-shoots in the Abdulla Kheli forest, Baluchistan, measured in 1912–13, reached a height of 16 ft. in five years.

ORDER XL. APOCYNACEAE

This large order contains one or two trees and shrubs of interest in Indian forestry, as well as a large number of climbers, some noxious, some ornamental. Most of the species have milky juice, and some are producers of caoutchouc. Attention was drawn some years ago to the possibilities as a rubber-producing plant of the Burmese climber *Urceola esculenta*, Benth. (syn. *Chavannesia esculenta*, DC.), but experiments have shown that the quantity of rubber yielded does not pay for the labour of obtaining it. *Chonemorpha macrophylla*, G. Don, a widely distributed climber of the moist forests of India, yields a form of caoutchouc, but is not exploited. *Parameria glandulifera*, Benth. (vern. *Talaingsôk*, Burm.), a large climber of the coasts of Tenasserim and the Andamans, is said to yield caoutchouc of good quality. Of non-Indian rubber-producing plants the best known are species of *Landolphia* and *Kickxia* and *Funtumia elastica*, Stapf.

Among familiar climbers of the forest and waste lands may be mentioned *Vallaris Heynei*, Spreng., and *Ichnocarpus frutescens*, R. Br. A strikingly handsome climber, which is frequently grown in gardens, and produces masses of large bell-shaped flowers, is *Beaumontia grandiflora*, Wall., a native of the eastern Himalaya, Sylhet, and Chittagong. It grows rapidly and is easily propagated from seed, cuttings, or layers.

Genera 1. HOLARRHENA, R. Br.; 2. ALSTONIA, R. Br.; 3. WRIGHTIA, R. Br.; 4. CARISSA, Linn.

1. HOLARRHENA, R. Brown.

Holarrhena antidysenterica, Wall. Syn. *H. Codaga*, G. Don; *Chonemorpha antidysenterica*, G. Don. Vern. *Dudhi, karra, kura, kachri*, Hind.; *Kuda*, Mar.; *Kodaga*, Mar.; *Lettôkgyi*, Burm. (Fig. 253.)

A small deciduous tree with opposite entire leaves. Bark greyish brown, scaly. Wood white, soft, even grained, used for carving into picture-frames, domestic utensils, and fancy articles of various kinds. The bark and seeds (*indarjau*, Hind.) are used medicinally. The tree is of interest and importance in Indian forestry from its great abundance and wide distribution, in which respect it is a useful accessory species in clothing the ground and acting as a nurse to more valuable species: the tree is important for reclothing waste lands.

DISTRIBUTION AND HABITAT. Widely distributed throughout India and Burma in deciduous forests and open waste lands, where it is often gregarious. It ascends the outer Himalayan valleys to 4,000 ft., and is abundant in the sal and mixed deciduous forests of the sub-Himalayan tract, being one of the component species of the mixed type of forest representing the transition stage between the riverain forests of *Acacia Catechu* and *Dalbergia Sissoo* and the sal forests on older and more elevated land. It is also a common species in the mixed deciduous forest of the dry *bhabar* tract skirting the base of the outer hills. It is common throughout the greater part of the Indian Peninsula, down to Malabar and Travancore.

In Burma it is fairly common in dry open mixed forests, often on laterite, and in *indaing* (dry dipterocarp) forest. It reaches the dry zone of Burma, but is probably absent from the drier parts of that zone.

Within its habitat the absolute maximum shade temperature varies from 105° to 118° F., the absolute minimum from 30° to 55° F., and the normal rainfall from 30 to 150 in.

LEAF-SHEDDING, FLOWERING, AND FRUITING. The leaves turn yellow about December–January and fall about January–February, the tree remaining leafless until the new leaves appear about April. The flowering period is somewhat variable: flowering may commence as early as April, but usually takes place in May and June, sometimes continuing until July and August, when flowers may be found along with nearly full-sized unripe fruits. The white flowers, which are arranged in terminal corymbose cymes, are very fragrant. The fruits are pairs of slender follicles 8–16 in. long: they develop rapidly after the flowering is over, and are full-sized by August to October, but do not ripen until February to April, when they dehisce on the tree, and the numerous seeds escape. The seeds (Fig. 255, *a*) are 0·5–0·8 in. long, linear, light brown, with a thin, somewhat brittle, closely adhering testa, and crowned at one end with a coma of pale brown silky hairs 1·5–2 in. long, with the aid of which the seeds are distributed to some distance by the wind: 900–1,000 seeds weigh 1 oz., and there are usually about 25–30 in each follicle. Fresh seed has a high percentage of germination, but a considerable proportion loses its vitality if kept for one year.

Flowering and fruiting begin at an early stage in the life of the tree. A nursery-raised seedling at Dehra Dun, from seed sown in May 1911, flowered

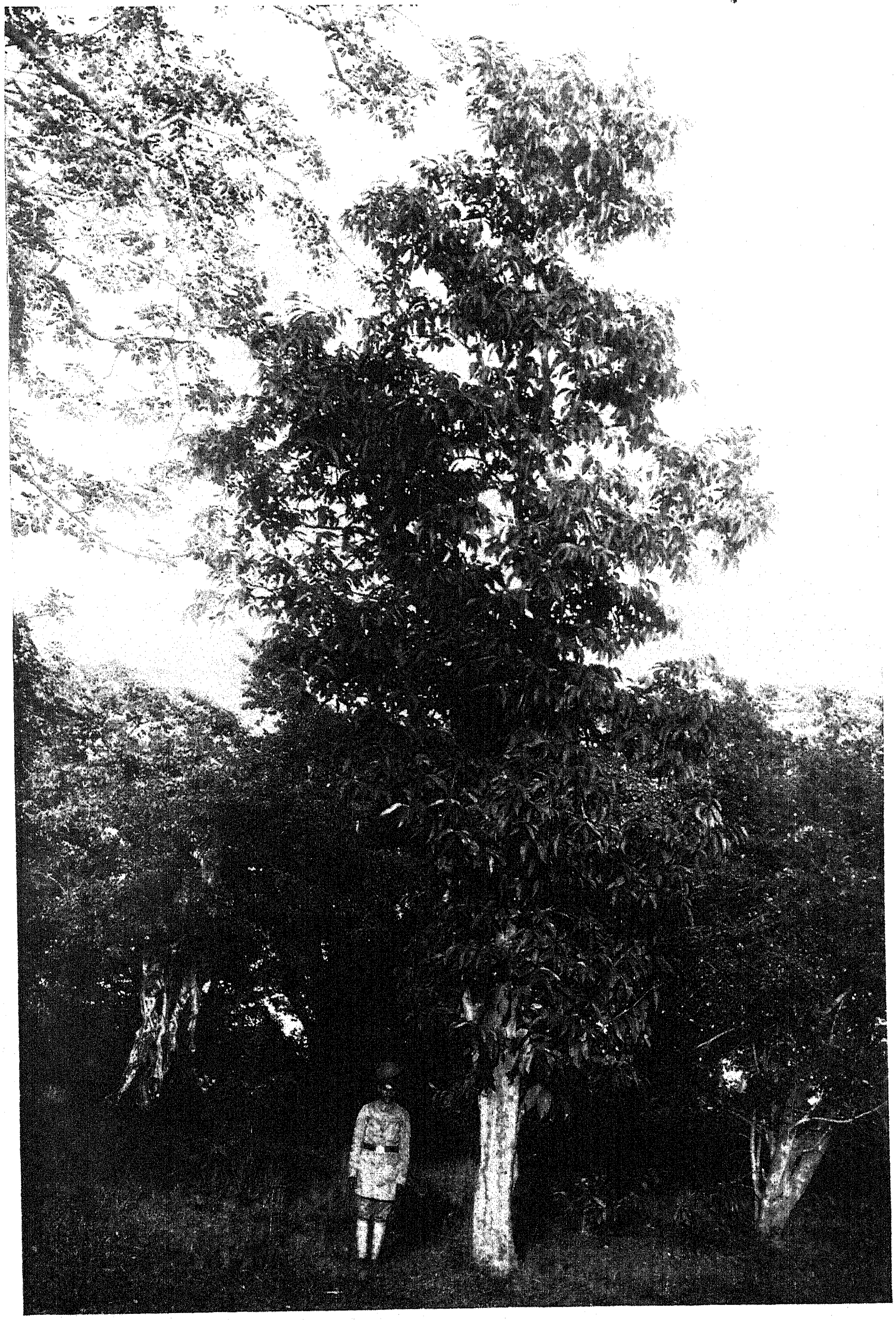

FIG. 253. *Holarrhena antidysenterica* in fruit, Dehra Dun, United Provinces.

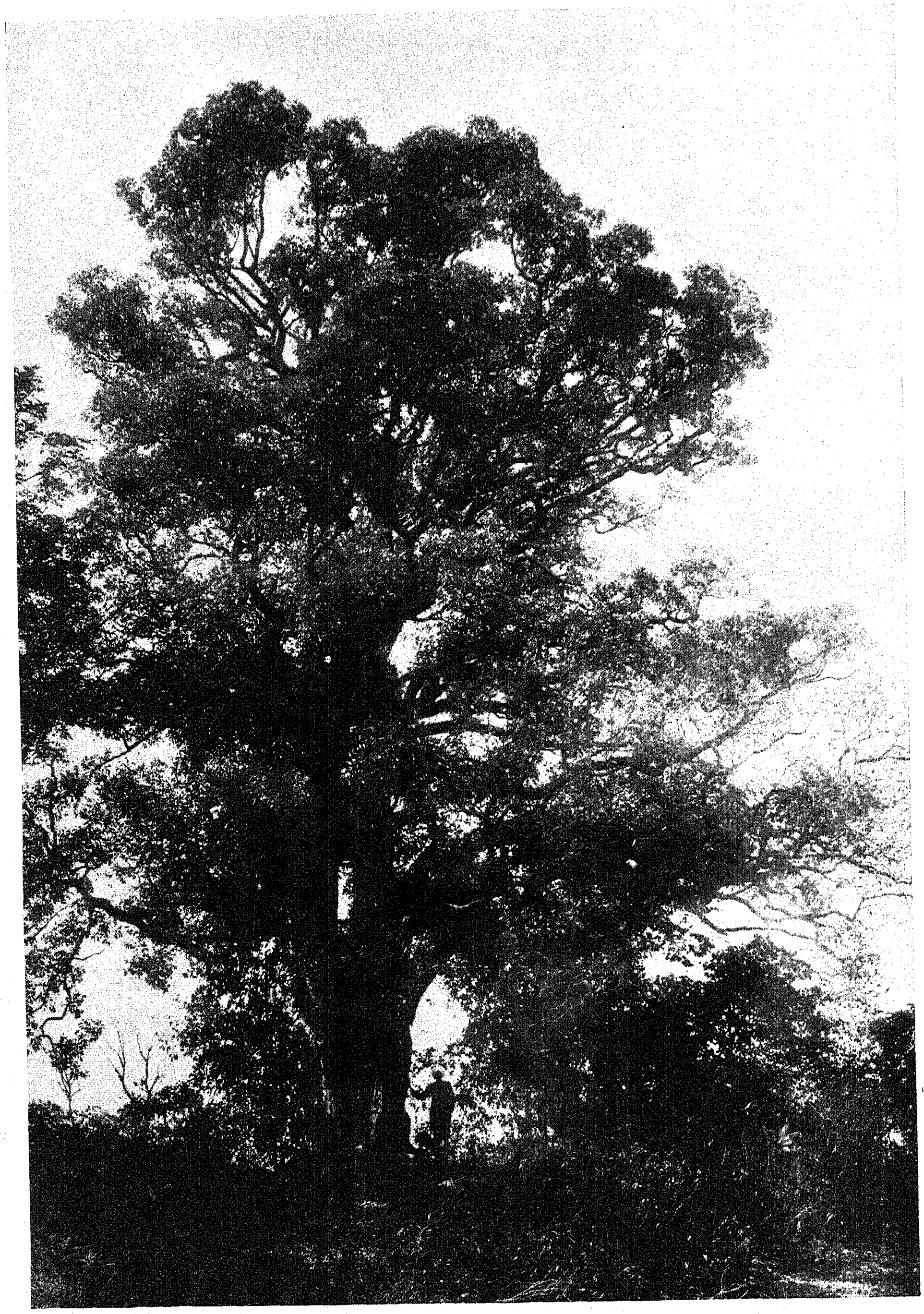

FIG. 254. *Alstonia scholaris*, Dehra Dun, United Provinces.

for the first time in May 1913 and bore numbers of good fruits in February–March 1914. Under natural conditions, where the plants do not develop so vigorously, flowering does not take place so early, as has been observed in the case of plants grown under natural conditions at Dehra Dun: in the forest, however, plants still in the condition of shrubs may often be observed in flower.

GERMINATION (Fig. 255, *b–f*). Epigeous. The radicle emerges from the end of the seed: the hypocotyl arches slightly, soon straightening and carrying above ground the cotyledons with the testa usually enclosing their extremities. The cotyledons, which are convolute in the seed, unroll themselves and expand, and the testa then falls to the ground, often adhering for some time to one of them before falling.

THE SEEDLING (Fig. 255).

Roots: primary root moderately long, terete, tapering, wiry, white turning yellow or light brown, pubescent: lateral roots numerous, moderately long, fibrous, pubescent, distributed down main root. *Hypocotyl* distinct from root, 1·2–2 in. long, terete, tapering upwards, white turning green, minutely pubescent. *Cotyledons*: petiole less than 0·1 in. long, channelled above, pubescent: lamina 0·9–1·1 in. by 0·5–0·7 in., foliaceous, cordate, acute, entire, bright green, glabrous, or slightly pubescent near the base on the under side, convolute in the seed, 5-veined from the base, the three central veins more prominent than the two lateral veins, subsidiary veins reticulate. *Stem* erect, terete, woody, pubescent; internodes 0·5–1·3 in. long. *Leaves* simple, opposite, exstipulate. Petiole 0·15 in. long, channelled above. Lamina 1·7–3·5 in. by 0·6–1·3 in., ovate lanceolate, acute or acuminate, base acute and slightly decurrent, entire, glabrous, lateral veins 6–9 pairs.

Under natural conditions the seedling grows somewhat slowly during the first season, as a rule reaching a height of about 4 to 6 in. by the end of the year; in subsequent years the growth is more rapid. Weeding and watering greatly stimulate growth. Seedlings are frost-tender and are also liable to be killed by drought during the first season, mortality from the latter cause being considerable. Young plants are fairly light-demanding, and suffer from suppression: they are sometimes liable to serious defoliation by caterpillars. The leaves of seedlings fall from December to February, new growth commencing in March (northern India).

The following measurements in experimental plots at Dehra Dun give some indication of the rate of growth of young plants under different conditions:

Holarrhena antidysenterica: development of seedlings, Dehra Dun.

Condition under which grown.	Height at end of season. 1st season.	2nd season.	3rd season.	4th season.
(1) Nursery plant, weeded and watered	1 ft. 5 in.	6 ft. 6 in.	10 ft. 5 in.	13 ft. 0 in.
(2) Transplants of first rains, not weeded or watered after transplanting	Maximum 1 ft. 6 in.	Maximum 3 ft. 2 in.	1 ft. 9 in.–4 ft. 0 in.	..
(3) Broadcast sowing, weeded, not watered	,, 0 ft. 5 in.	,, 1 ft. 2 in.	Maximum 3 ft. 9 in.	..
(4) Line sowings, weeded, not watered	,, 0 ft. 7 in.	,, 1 ft. 6 in.	..	..
(5) Natural conditions (among weeds)	,, 0 ft. 4½ in.	,, 1 ft. 7 in.	1 ft. 10 in.	5 ft. 5 in.

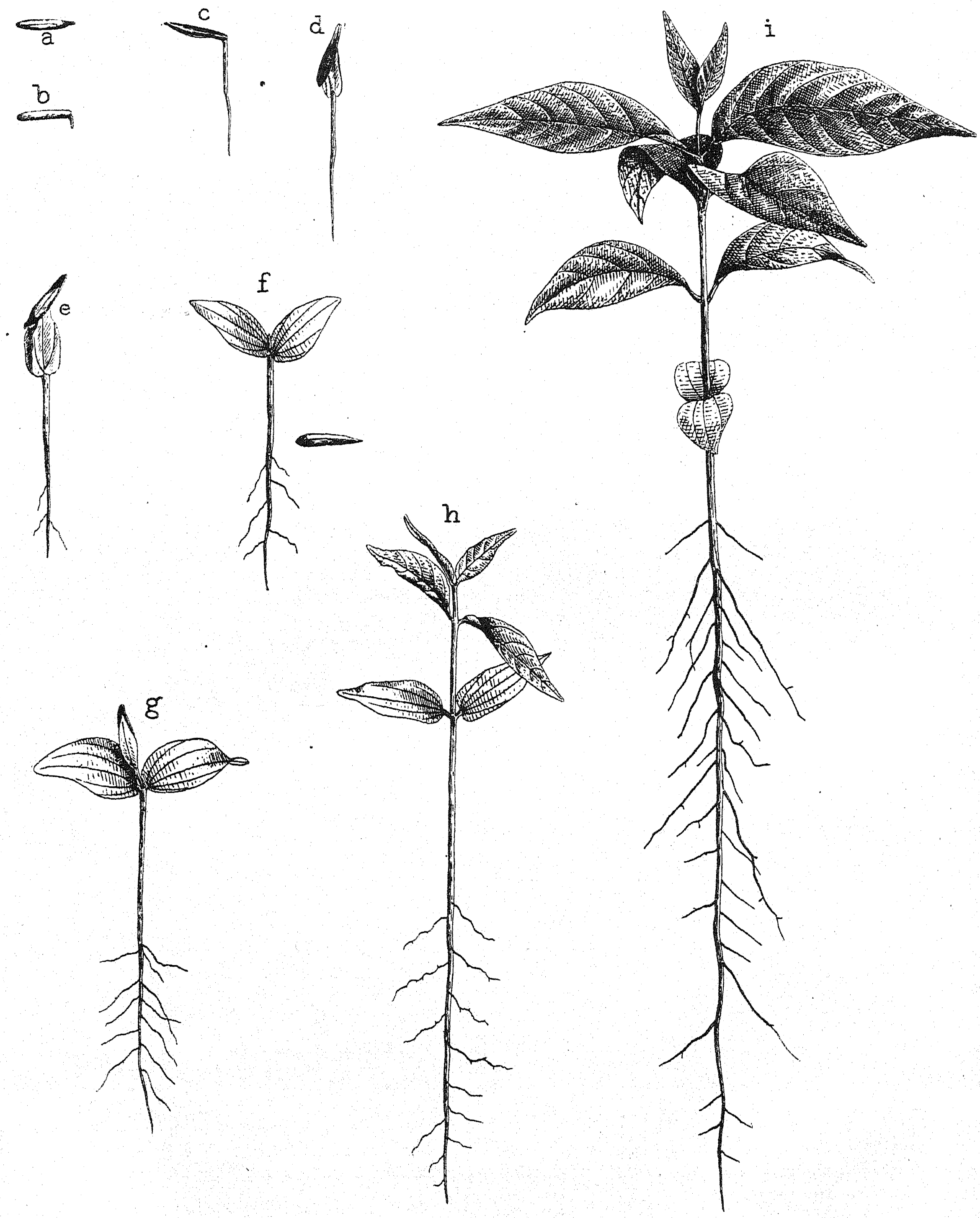

FIG. 255. *Holarrhena antidysenterica.* Seedling × $\frac{5}{8}$

a, seed (without coma); *b–f*, germination stages; *g–i*, development of seedling to end of first season.

Silvicultural characters. The tree stands a slight amount of shade, but develops best in full light. In the abnormal drought of 1907 and 1908 in the forests of Oudh it proved to be decidedly hardy. It is sensitive to frost, but has good powers of recovery from the base when killed down, and may often be found in abundance persisting on grassy areas subject to severe frost. It is not readily browsed, even by goats. It coppices well, and shoots up readily after severe damage by fire. It produces root-suckers in abundance.

Natural reproduction. Under natural conditions germination takes place during the rainy season, chiefly at the beginning of that season. In their earlier stages many seedlings are destroyed by drought, and frost often keeps the young growth back. Nevertheless this species regenerates with great freedom, owing partly to its regular and abundant seeding from an early age, partly to its comparative immunity from damage by grazing, and partly to its power of recovery from injury of all kinds. In the open grass-lands so common in sal forests it often appears in great abundance with fire-protection, and is a most useful nurse for the sal seedlings, which appear underneath it and gradually make their way through it.

Artificial reproduction. The tree can be raised artificially without difficulty both by direct sowing and by transplanting from the nursery. Experiments at Dehra Dun have shown that great success can be attained by line sowings along with field crops, provided that a strip about 2 ft. wide is kept clear of field crops along the line, the crops being sown in the intervening spaces; regular weeding along the lines is necessary during the first two or three years, and loosening of the soil from time to time is advantageous; as the seedlings are apt to form a dense line they should be thinned out periodically.

For transplanting purposes seed should be sown in the nursery in March or early April: the seedlings ordinarily appear in two or three weeks, and are ready for transplanting in the first rainy season.

Rate of growth. High forest sample plots in the United Provinces show mean annual girth increments of 0·05, 0·12, 0·13, 0·14, 0·28, and 0·41 in., but these figures are probably misleading, as they refer chiefly to small-sized trees in sal sample plots, and have evidently been thoroughly suppressed, in the first four instances at all events. A cross-section from the United Provinces in the silvicultural museum at Dehra Dun had 60 rings for a girth of 3 ft. 6 in., giving a mean annual girth increment of 0·7 in. Gamble's specimens showed 7 to 8 rings per inch of radius, giving a mean annual girth increment of 0·78 to 0·9 in.

Various coppice measurements have been recorded. Measurements made in 1911 in Gonda, United Provinces, gave an average height of 5·1 ft. as against 4·7 ft. for sal in a coupe one year old, and 6·8 and 5 ft. as against 10 and 7·6 ft. for sal in two coupes two years old. Measurements by Mr. A. F. Broun in 1886 in a coppice coupe nine years old near Dehra Dun gave an average height of 15·5 ft. as against 16 ft. for sal, and an average girth of 8 in. as against 8·6 in. for sal.

Measurements made in 1910 by Mr. C. M. McCrie in coppice coupes in the Gorakhpur district, United Provinces, gave the following results for *Holarrhena* as compared with sal:

Holarrhena antidysenterica: measurements in coppice coupes, Gorakhpur.

	Mean height.		Mean girth.			Mean height.		Mean girth.	
Age.	*Holarrhena.*	Sal.	*Holarrhena.*	Sal.	Age.	*Holarrhena.*	Sal.	*Holarrhena.*	Sal.
years.	ft.	ft.	in.	in.	years.	ft.	ft.	in.	in.
2	4·0	3·0	..	..	10	12·0	15·3	3·7	4·8
4	6·5	7·0	1·7	2·0	12	13·6	17·5	4·3	5·8
6	8·5	10·3	2·5	2·9	14	15·2	19·2	4·8	6·7
8	10·4	13·0	3·2	3·8	16	16·8	20·9	5·3	7·5

2. ALSTONIA, R. Br.

Alstonia scholaris, R. Br. Vern. *Satni, satian,* Hind.; *Satwin,* Mar.; *Mudhol,* Kan.; *Eda kula,* Tel.; *Palai,* Tam.; *Lettôk, taungmèôk,* Burm. (Fig. 254.)

A large evergreen tree with a tall stem, often fluted and buttressed, whorled branches, and dark green shiny leaves in whorls of 4 to 10. Bark grey, yellow inside, exuding milky juice when cut. Wood soft, white, used for boxes, scabbards, writing-boards, &c.

Scattered throughout the greater part of India and Burma where the rainfall is over 50 in., preferring fairly moist situations; not in the dry regions. The tree is nowhere very abundant or gregarious. Fl. December to March; fr. May to July. The fruits consist of pairs of slender follicles 1–2 ft. long, hanging in clusters, containing numerous densely ciliate seeds.

The only measurement of the rate of growth available is one made in Gorakhpur, United Provinces, showing an average height of 6 ft. 8 in. for coppice three years old.

3. WRIGHTIA, R. Br.

Species 1. *W. tomentosa,* Roem. and Sch.; 2. *W. tinctoria,* R. Br.

1. **Wrightia tomentosa,** Roem. and Sch. Syn. *W. mollissima,* Wall.; *W. Wallichii,* A. DC. Vern. *Dudhi, keor, darbela,* Hind.; *Kala indarjau,* Mar.; *Tella pala,* Tel.; *Pala,* Tam.; *Lettôkthein,* Burm.

A small deciduous tree with slender pubescent branches and opposite distichous softly tomentose leaves. Bark grey, corky, exuding a yellowish white latex when cut. Wood white, moderately hard, even-grained, used for turning, carving, domestic utensils, &c.

Distribution and habitat. Distributed throughout the greater part of India and found in various parts of Burma, but not so common or so gregarious as *Holarrhena antidysenterica.* In the sub-Himalayan tract it is rare west of the Beas; it ascends the outer valleys to 4,000 ft., and extends eastward to Assam. It is common on the boulder deposits of the dry *bhabar* formation skirting the base of the outer hills. In Chota Nagpur and the Central Provinces it is somewhat local and nowhere abundant, and throughout the Peninsula generally it is distributed more or less locally. It occurs commonly in rather open mixed deciduous forests, and also in sal forest. In Burma it is fairly common in mixed deciduous forests of the upper and lower types.

Within its habitat the absolute maximum shade temperature varies from 105° to 118° F., the absolute minimum from 30° to 55° F., and the normal rainfall from 35 to 150 in.

LEAF-SHEDDING, FLOWERING, AND FRUITING. The leaves fall during January and early February, and the trees are leafless during February, March, and part of April, the new leaves appearing in April–May. The yellowish white flowers, with red coronal scales, in corymbose cymes, appear from April to June. The fruit consists of two connate many-seeded follicles joined into a single pendulous grooved cylindrical pod 6–12 in. long and 0·5–0·7 in. thick, rough with white specks ; the follicles separate before dehiscing. The fruits are usually full-sized by August, but do not ripen and dehisce until from January to March or even April. The seeds (Fig. 256, *a*) are 0·5–0·7 in. long, linear, light yellowish grey, crowned with a tuft of white silky hairs by the aid of which they are disseminated by the wind : about 1,500–1,700 seeds weigh 1 oz. Fresh seeds have a high percentage of fertility, but if kept for a year they lose their vitality.

GERMINATION (Fig. 256, *b–e*). Epigeous. The radicle emerges from the end of the seed and the hypocotyl elongates, carrying above ground the cotyledons enclosed in the testa. The cotyledons, which are convolute in the seed, unroll themselves and expand, and the testa then falls to the ground, or clings to the edge of one cotyledon for some little time before falling.

THE SEEDLING (Fig. 256).

Roots : primary long, terete, wiry, flexuose : lateral roots numerous, fibrous, distributed down main root. *Hypocotyl* distinct from root, terete, tapering slightly upwards, finely pubescent. *Cotyledons* : petiole 0·1 in. long, flattened above, finely pubescent : lamina 0·6–0·8 in. by 0·5–0·7 in., foliaceous, slightly fleshy, cordate, acute, entire, green, glabrous above, minutely pubescent beneath, convolute in the seed. *Stem* erect, terete, tomentose ; internodes 0·4–0·8 in. long. *Leaves* on main stem opposite, sub-opposite or alternate, exstipulate. Petiole up to 0·1 in. long, finely tomentose. Lamina 0·8–2·5 in. by 0·5–0·8 in., ovate- or elliptical-lanceolate, acuminate, entire, finely tomentose on both surfaces, lateral veins 5–10 pairs.

Under natural conditions the growth of the seedling during the first season is moderate, a height of about 3–10 in. being attained : subsequently the growth is more rapid provided it is not interfered with by weeds, which exercise an adverse influence on the development of the young plant. Weeding and watering stimulate rapid growth from the commencement, seedlings regularly weeded and watered at Dehra Dun having reached a height of as much as 3 ft. 5 in. to 3 ft. 10 in. by the end of the first season. These vigorous plants, whose further growth is recorded below, produced flowers, from which no fruits developed, at the end of the second season, while at the end of the third season flowers were produced which resulted in the formation of fertile fruits.

The seedlings are decidedly sensitive to frost, but though liable to be killed back they have good power of recovery. In northern India the season's growth ceases about October–November, new growth starting in March–April ; the leaves commence falling in October–November and the seedlings are leafless from December to March.

The following measurements in experimental plots at Dehra Dun give some indication of the rate of growth of young plants and the beneficial effect of weeding :

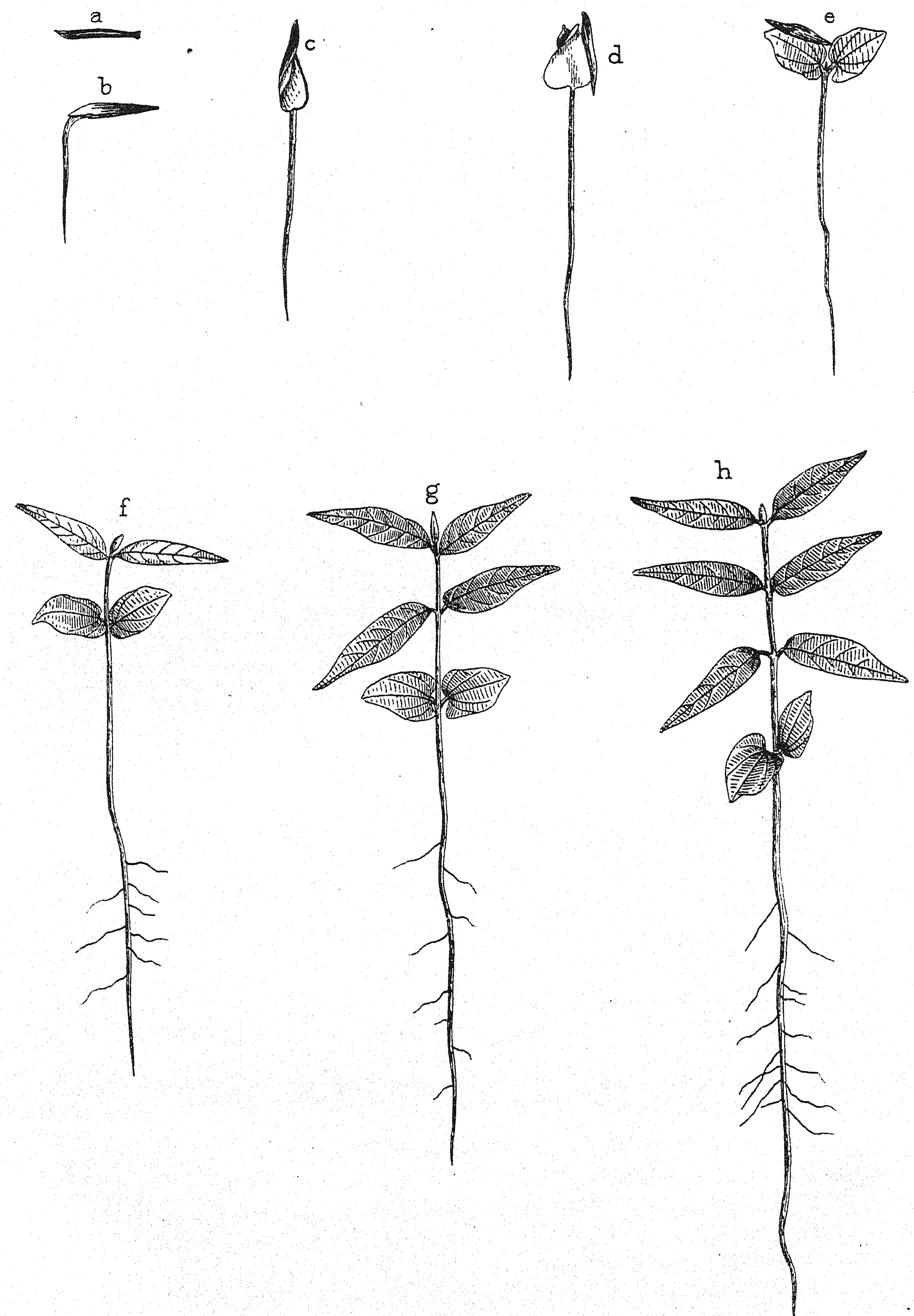

FIG. 256. *Wrightia tomentosa.* Seedling × $\frac{3}{4}$.

a, seed (without coma); *b–e*, germination stages; *f–h*, development of seedling during first season.

Wrightia tomentosa: development of seedlings, Dehra Dun.

Condition under which grown.	Height at end of season. 1st season.	2nd season.	3rd season.	4th season.
(1) Transplants, not weeded or watered	Maximum 0 ft. 11 in.	0 ft. 9 in.–2 ft. 0 in.	1 ft. 2 in.–2 ft. 8 in.	..
(2) Broadcast sowings, not weeded or watered	0 ft. 2 in.–0 ft. 4 in.	Maximum 0 ft. 7 in. (Growth much impeded by grass and weeds)	Maximum 1 ft. 9 in.	..
(3) Broadcast sowings, weeded, not watered	Maximum 0 ft. 11 in.	Maximum 2 ft. 10 in. (Seedlings crowded, the larger suppressing the smaller)	0 ft. 5 in.–6 ft. 0 in.	..
(4) Nursery sowings, regularly weeded and watered	3 ft. 5 in.–3 ft. 10 in.	8 ft. 6 in.–9 ft. 0 in.	12 ft. 5 in.–12 ft. 9 in.	Maximum 15 ft. 0 in.

Silvicultural characters. The tree is a moderate light-demander, and is often found as an undergrowth species in open deciduous forest. In the abnormal drought of 1907 and 1908 in the forests of Oudh it proved to be fairly hardy, though not so hardy as *Holarrhena*. It coppices well, and has good power of recovery from injury. It is somewhat frost-tender.

Natural reproduction. Under natural conditions germination takes place at different times during the rainy season. Some mortality occurs among seedlings owing to drought during breaks in the rains. Reproduction is most plentiful on clear loose ground free from weed-growth.

Artificial reproduction. Weeded line sowings carried out as in the case of *Holarrhena* give good results. For transplanting purposes seed should be sown in the nursery about March or April: the seedlings ordinarily appear above ground in three to four weeks, and may be transplanted during the first rainy season, but care is necessary during transplanting, otherwise they are liable to die back or to be killed outright.

Rate of growth. A cross-section in the silvicultural museum at Dehra Dun had 31 rings for a girth of 2 ft. 5 in., giving a mean annual girth increment of 0·94 in. Gamble's specimens gave an average of 8 rings per inch of radius, or a mean annual girth increment of 0·78 in. Measurements of one tree extending over a period of nine years in the Kishanpur working circle, South Kheri, United Provinces, gave a mean annual girth increment of 0·4 in. for the period.

2. **Wrightia tinctoria,** R. Br. Vern. *Khirni*, *dudhi*, Hind.; *Kala kuda*, Mar.; *Vepala*, Kan.; *Tedlapal*, *repala*, Tel.; *Nila palei*, Tam.

A small deciduous tree of the Indian Peninsula, extending northward to Rajputana and Banda. This is a common tree in the Deccan in open deciduous forests, often on trap; it extends southward in considerable abundance to Travancore, and is found most commonly on dry sandy soil and on hilly ground. It is also found in Burma. The new leaves and white flowers appear from March to June and the fruit ripens in January–February. The fruit consists of a pair of slender follicles cohering at the tips only. The tree stands moderate shade, and is often found as an undergrowth species in deciduous forests. It produces root-suckers. The growth is slow to moderate. A cross-section in the silvicultural museum at Dehra Dun had 24 rings for a girth of 11 in., giving a mean annual girth increment of 0·46 in. Gamble's specimens gave 7 rings per inch of radius, or a mean annual girth increment of 0·9 in.

4. CARISSA, Linn.

Species 1. *C. spinarum*, A. DC.; 2. *C. Carandas*, Linn.

1. **Carissa spinarum,** A. DC. Syn. *C. diffusa*, Roxb. Vern. *Karaunda*, Hind.; *Kavali*, Kan.; *Kalivi*, Tel.; *Kan*, Burm.

An evergreen shrub with green branchlets and pairs of divaricate thorns at the nodes. The wood is hard and close grained, and is used for turning, combs, &c. The leaves have shown promise as a tanning material. This gregarious shrub is common in the drier forest tracts throughout India, ascending the outer Himalaya to 4,000 ft. It is common in the scrub forests of the dry zone of Burma. It springs up readily not only in open places but also as an undergrowth species, and is useful for clothing dry rocky ground. Although readily browsed by sheep and goats it persists in a remarkable manner; bovine animals do not appear to be so partial to it. In some of the heavily grazed tracts of Oudh it forms a dense undergrowth, developing into a small tree high enough to enable cattle to wander underneath. In such places it is almost the only species which survives the heavy grazing and the trampling of the soil; its dense shade kills out the grass and ruins the grazing.

The small white star-like flowers appear in the hot season, from April to June; they are extremely fragrant, especially in the evening. The fruits ripen in the cold season; they are dark purple, edible, sweetish juicy berries, and are readily eaten by birds, which scatter the seeds. Under natural conditions the seeds germinate during the rainy season; with abnormal rain some may germinate as early as March, but in this case the seedlings usually die of drought in the subsequent hot weather. The seedlings have good power of penetrating grass and weed-growth, but succumb to excessive damp.

The growth of the seedling is slow, a height of about 2 to 3 in. being attained in the first season, about 6 to 8 in. in the second season, and about 10 to 13 in. in the third season.

The shrub coppices well and produces root-suckers freely; its power of spreading by root-suckers no doubt accounts in part for its persistence in spite of heavy grazing. It is frost-hardy, and in the abnormal drought of 1907 and 1908 in the forests of Oudh it proved decidedly drought-resistant. It stands moderate shade. The growth is somewhat slow; coppice-shoots ten years old near Dehra Dun had an average height and girth of 8 ft. and 2 in. respectively. Gamble's specimens showed 8 to 15 rings per inch of radius, giving a mean annual girth increment of 0·42 to 0·78 in.

2. **Carissa Carandas,** Linn. Vern. *Karaunda*, Hind.

This species resembles *C. spinarum*, but is usually a larger shrub or a small tree with larger leaves and fruits. It is frequently cultivated.

ORDER XLI. ASCLEPIADACEAE

This order is of interest mainly as containing a number of forest climbers, a few of some importance as fibre plants and several noxious to tree-growth. Among the best known are *Cryptolepis Buchanani*, Roem. and Sch., a very common climber which in some forest tracts gives a good deal of trouble; *Dregea volubilis*, Benth., a very troublesome climber in the riverain forests of

Acacia Catechu and *Dalbergia Sissoo* in some parts of the sub-Himalayan tract (see Fig. 122), *Marsdenia Roylei*, Wight, and *M. tenacissima*, W. and A., which yield strong silky white fibres. The seeds of species of this order are scattered by wind, as they are usually winged and crowned with a dense coma.

Genera 1. Cryptostegia, R. Br.; 2. Calotropis, R. Br.

1. CRYPTOSTEGIA, R. Br.

Cryptostegia grandiflora, R. Br.

A large climber, probably a native of Madagascar, often cultivated or run wild in India. It yields a fairly good quality of caoutchouc, and for some years past attempts have been made to cultivate it in the outer hills of the Punjab: although it has been found to grow tolerably well it suffers from excess both of heat and of cold, the young shoots dying off, though new shoots are again sent out. It grows well in pure sand in Jaipur, Rajputana, with a rainfall of about 20 in., and is recommended for planting shifting sands on the plains: transplanting should be carried out during the rainy season when the ground has been soaked with rain.

2. CALOTROPIS, R. Br.

Species 1. *C. gigantea*, R. Br.; 2. *C. procera*, R. Br.

1. **Calotropis gigantea,** R. Br., and 2. **Calotropis procera,** R. Br.

Well-known and widely distributed shrubs with milky juice and leaves covered beneath with a white felty tomentum. They furnish useful fibres from the stem, and the hair of the seeds is used for stuffing cushions. Owing to their silky coma the seeds are carried to a considerable distance by the wind, and the plants spring up readily on open ground and waste places. *C. procera* in particular springs up in abundance on new sandy or gravelly alluvium in the beds of rivers and is a common forerunner of riverain forests of *Acacia Catechu* and *Dalbergia Sissoo*. The flowers and fruits appear at various times, but chiefly in the cold and hot seasons.

ORDER XLII. LOGANIACEAE

Genera 1. Strychnos, Linn.; 2. Fagraea, Thunb.

1. STRYCHNOS, Linn.

Species 1. *S. Nux-vomica*, Linn.; 2. *S. Nux-blanda*, A. W. Hill; 3. *S. potatorum*, Linn. f.

1. **Strychnos Nux-vomica,** Linn. Strychnine, nux-vomica or snakewood tree. Vern. *Kuchla*, *kajra*, Hind.; *Kar*, Mar.; *Kasarkana*, Kan.; *Mushti*, Tel.; *Yetti*, Tam.

A moderate-sized or large handsome evergreen or deciduous tree with opposite smooth shining leaves five-nerved from the base, the three central nerves being prominent. Bark yellowish grey to blackish grey, thin, smooth, covered with minute tubercles and containing chlorophyll tissue. The seeds of this tree are the nux-vomica of commerce, and are of importance in yielding the alkaloids strychnine and brucine. They are largely collected for sale;

fresh clean silvery seeds collected from the ripe fruits command a higher price than the dull-coloured seeds collected off the ground.

DISTRIBUTION AND HABITAT. The Indian Peninsula northward to the Circars, Orissa, Raipur, South Chanda, and the Konkan. Common in southern India. Occasional in Chota Nagpur, but always near villages, and probably not indigenous (Haines). Gorakhpur forests in the United Provinces (Brandis). Dry region of Ceylon.

In the Indian Peninsula it is common in many localities in deciduous forests, usually of a moist type. Talbot says that in Bombay it is very common in the moist monsoon forests of the Konkan and North Kanara, and abundant on laterite along the sea-coast in evergreen thorn scrub. In the Central Provinces it occurs chiefly on deep alluvial soils in South Chanda and on the quartzite plateau of the Laun range, Raipur (Haines).

Within its habitat the absolute maximum shade temperature varies from 96° to 118° F., the absolute minimum from 40° to 65° F., and the normal rainfall from 35 to 150 in. or more.

LEAF-SHEDDING, FLOWERING, AND FRUITING. In moist types of forest the tree is evergreen, but in dry types, for example on laterite, it loses its leaves for a short time in the hot season. The small greenish white flowers appear from March to May, and the fruits ripen in the cold and hot seasons from December to June. The fruit is a berry about the size and colour of a small orange, with a rather hard coriaceous pericarp and a bitter white pulp in which are a number of nearly circular flat seeds.

The seeds are poisonous, but the pulp and even the seeds are eaten by langur monkeys. Gamble says: ' The pulp of the fruit, though containing also some poison, is eaten by the langur monkeys (*Semnopithecus entellus*, Blyth, and *S. priamus*, And.) and also by the Malabar pied hornbill (*Anthracoceros coronatus*, Elliot), and perhaps by other hornbills, parrots, and other birds, but the seeds are probably always rejected or else passed undigested. But while the langur monkeys can apparently eat the fruit and even the seeds without harm, other monkeys, as well as other animals and man, cannot do so, though it is said that the flying fox can eat the pulp with impunity.'

SILVICULTURAL CHARACTERS. The tree is a shade-bearer, growing under a moderate canopy even in semi-evergreen types of forest. It produces root-suckers. It is immune from damage by browsing, as animals avoid it.

RATE OF GROWTH. Little is known regarding the rate of growth. A cross-section in the silvicultural museum at Dehra Dun had 31 rings for a girth of 2 ft. 3 in., giving a mean annual girth increment of 0·87 in.

2. **Strychnos Nux-blanda,** A. W. Hill. Burmese strychnine tree. Vern. *Kabaung*, Burm.

A moderate-sized evergreen or deciduous tree with opposite smooth shining leaves five-nerved from the base, the three central nerves being prominent. Bark yellowish grey to blackish grey, often fluted.

DISTRIBUTION AND HABITAT. Burma, common in the upper and lower mixed deciduous forests, and often very plentiful in moist semi-evergreen forest as a lower story beneath *Dipterocarpus alatus* and other tall trees. It is also common in *indaing* (dry dipterocarp) forest on laterite, though here

FIG. 257. *Strychnos Nux-blanda*—SEEDLING × $\frac{3}{8}$

a—Seed b - g Germination stages h—Seedling early in second season

it is usually a small tree. It enters the dry zone of Burma, but is not found in the driest parts.

Leaf-shedding, flowering, and fruiting. As a rule the tree loses its leaves for a short time in the hot season, though in moist localities it is evergreen. The small greenish white flowers appear in April–May and the fruits ripen in the cold season. The fruit is a berry about the size of a small orange, with a rather hard coriaceous orange-coloured pericarp and a whitish pulp in which are a number of seeds. The seeds (Fig. 257, *a*) are 0·6–1 in. by 0·5–0·8 in., nearly circular, flat, light yellowish grey with a satiny lustre and a soft felty testa; about 250–350 weigh 1 lb. The seeds retain their vitality to some extent for a year; in a test carried out at Dehra Dun 50 per cent. of seeds kept for one year germinated. As a rule the tree fruits well every year.

Germination (Fig. 257, *b–g*). Epigeous. The radicle emerges from one end of the seed and descends rapidly, forming a thick yellowish white taproot. The hypocotyl subsequently elongates with little or no arching, carrying above ground the cotyledons enclosed in the testa, within which is a layer of albumen. The testa is pushed towards the tips of the cotyledons with their expansion, and usually adheres to the apex of one of them for some little time before finally dropping to the ground.

The seedling (Fig. 257).

Roots: primary root long, thick, terete, only slightly tapering, yellowish white or light brown, at first delicate in texture, afterwards woody: lateral roots moderate in number to numerous, short, fibrous, distributed down main root. *Hypocotyl* distinct from root, 2·2–3 in. long, terete, tapering slightly upwards, green, glabrous. *Cotyledons* sessile, 1·5–2·7 in. by 1·3–2·5 in., foliaceous, broadly ovate, acute or slightly acuminate, entire, green, glabrous, shining, prominently 5-veined from the base. *Stem* erect, terete or slightly compressed, green, glabrous. *Leaves* simple, opposite. Petiole about 0·1 in. long. Lamina, first pair 1·2–1·5 in. by 1–1·3 in., broadly elliptical, acute, base rounded, entire, dark green, glabrous, shining; subsequent leaves 3–3·5 in. by 1·4–1·7 in., elliptical, acuminate, base acute, dark green, glabrous, shining, prominently 3-veined from the base, with an additional pair of intra-marginal veins.

During the first season the growth of the seedling above ground is slow, development being confined to little or nothing more than the expansion of the large green leafy cotyledons: a long rather thick taproot of somewhat delicate texture is rapidly formed, and may reach a length of 8 or 9 in. within a month of germination. During the second season the growth of the seedling is more rapid. Seedlings are extremely sensitive to cold, and cannot exist if there is frost.

Silvicultural characters. The tree is a shade-bearer, growing up under a moderate canopy in deciduous and even in moist semi-evergreen forest. It is sensitive to cold, and does not grow in localities subject to frost.

Natural reproduction. The seed germinates readily with heat and moisture, and natural reproduction is often abundant, its establishment being aided by the immunity of the young plants from damage by browsing. The factors influencing natural reproduction require further study.

Artificial reproduction. Owing to the length and delicacy of the young taproot transplanting requires great care, and the best method of

carrying it out is to sow the seeds singly in long baskets or bamboo tubes and to transplant these bodily during the second rainy season. The young plants should be raised in free porous soil and should be kept under moderate shade while in the nursery.

3. **Strychnos potatorum,** Linn. f. Clearing-nut tree. Vern. *Nirmali*, Hind.; *Nivali*, Mar.; *Chili-gidda*, Kan.; *Chilla*, Tel.; *Tettancottai*, Tam.

A small to moderate-sized deciduous (or evergreen?) tree with a fluted stem, opposite coriaceous shining leaves, and lenticillate branchlets swollen at the nodes. Bark thick, blackish, corky, with deep vertical cracks. Unlike *S. Nux-vomica* this tree is not poisonous; the seeds are used to clear muddy water by rubbing the insides of vessels with them, and the pulp of the fruit is eaten. The wood is hard, close-grained, yellowish grey when seasoned, with conspicuous white markings, used for carts, shafts, agricultural implements, &c.

The tree is common in many of the dry deciduous forests of the Indian Peninsula. It is a shade-bearer, growing up well under the canopy of deciduous forest. It is drought-resistant, having remained unaffected in the severe drought of 1899–1900 in the Indian Peninsula. It produces root-suckers. The small white fragrant flowers, in axillary cymes, appear from February to May, and the fruits ripen from October to March. The fruit is a sub-globose berry 0·5–0·75 in. in diameter with a firm pericarp, black when ripe, with one or two seeds 0·4–0·5 in. in diameter in a whitish pulp. The seedling, like that of *S. Nux-vomica*, has a soft whitish delicate taproot.

2. FAGRAEA, Thunb.

Glabrous evergreen trees or shrubs, sometimes scandent, often epiphytic: seven known Indian species.

Fagraea fragrans, Roxb. Vern. *Anan*, Burm.

A moderate-sized handsome evergreen tree, usually less than 6 ft. in girth; bark 0·2–0·5 in. thick, grey to brown, with deep longitudinal cracks. Wood light brown, hard, very durable, said to withstand teredo, used for bridge and wharf piles, building, &c. Apart from the value of its timber the tree is useful for afforesting low-lying grassy tracts, and its handsome appearance makes it well suited as an ornamental shade tree.

The tree is very common in *indaing* (dry dipterocarp) forests of Tenasserim from Moulmein southwards, being particularly abundant in the Heinze basin of South Tenasserim, where there are said to be 200,000 tons available in lengths up to 60 ft.[1] It is found in the Andamans, and is common in the Malay Peninsula (vern. *Ternbusu*), where Mr. A. M. Burn-Murdoch[2] notes regarding it: 'The tree is widely distributed and will grow well in open places and even in *lalang* grass, being seldom met with in big forests. It grows easily from seed and is a fast grower. It is especially plentiful in parts of the Kuala Pilah district, also in Province Wellesley and Malacca, while there is an almost pure forest of this species on the east coast of Pahang, north of Kuantan near Baloh. There is a large plantation at Kuala Lumpur.' Mr. H. C. Hill[3]

[1] Ind. Forester, xxv (1899), p. 440.
[2] Trees and Timbers of the Malay Peninsula, Part II, p. 3.
[3] Reports on Forest Conservancy in the Straits Settlements and Federated Malay States, 1900.

says that in the Malay Peninsula it is very largely gregarious, coming up freely on grassy blanks and being easily propagated.

The fruit, a red berry about the size of a pea, ripens in Tenasserim about September–October. The seeds are minute.

ORDER XLIII. BORAGINACEAE

Genera 1. Cordia, Linn.; 2. Ehretia, Linn.

1. CORDIA, Linn.

This genus comprises about fifteen Indian trees and shrubs, some with very ornamental wood suitable for cabinet work. Some of these species deserve more study than they have yet received.

Species 1. *C. Myxa*, Linn.; 2. *C. vestita*, Hook. f. and Thoms.; 3. *C. Rothii*, Roem. and Sch.; 4. *C. Macleodii*, Hook. f. and Thoms.

1. **Cordia Myxa,** Linn. Syn. *C. obliqua,* Willd. Vern. *Lasora, bhokar, borla,* Hind.; *Buhal, bohari,* Beng.; *Bhokar, shelu,* Mar.; *Challe,* Kan.; *Iriki,* Tel.; *Vidi,* Tam.; *Thanat,* Burm.

A small or moderate-sized deciduous tree with variable orbicular, elliptical, oblong, or obovate coriaceous glabrous leaves, and often drooping branches. Bark greyish brown, smooth or longitudinally wrinkled. Wood moderately hard, not durable, used for boat-building, well-curbs, gun-stocks, &c.; a good fuel. The bast fibre is used for cordage. The leaves are used in Burma for cheroot-wrappers, and the tree is frequently grown round Burmese villages and pollarded for the production of leaves. Its mucilaginous fruits are eaten.

Distribution and habitat. Throughout India, Burma, and Ceylon, ascending in Himalayan valleys to 5,000 ft. It is not a gregarious tree, but is widely distributed, preferring moist shady ravines and the sides of valleys. It is found in a great variety of localities, from the dry forests of Sind and Rajputana to the moist deciduous forests of Burma and western India, and is often cultivated. In Burma it enters the tidal forests (Kurz). Within its habitat in India the absolute maximum shade temperature varies from 95° to 120° F., the absolute minimum from under 30° to over 60° F., and the normal rainfall from under 10 in. to 120 in. or more, though in the driest regions it exists by the aid of river water.

Leaf-shedding, flowering, and fruiting. The tree is leafless for a short time in the hot season. The small white polygamous flowers in loose corymbose cymes appear from March to May. The fruits ripen from June to August, some remaining on the tree through September (northern India). The fruit is a yellow or pinkish yellow shiny globose or ovoid drupe 0·5–1 in. long seated on the saucer-like enlarged calyx, and containing a hard one- or two-celled stone (Fig. 258, *a*) in a viscid edible pulp: the fruits turn black on ripening. About 120–160 stones weigh 1 oz. The trees are a striking sight when covered with the yellow fruits, which are eagerly eaten by monkeys and birds. Bourdillon (Travancore) says the fruits ripen from February to May, and Kurz (Burma) says March to April.

So far as tests carried out at Dehra Dun show, the seed has a rather low percentage of fertility, possibly owing to the fact that the stones are often

bored into and the seed destroyed by insects. It retains its vitality to some extent if kept for a year.

GERMINATION (Fig. 258, *b–f*). Epigeous, resembling that of *Tectona grandis* and *Gmelina arborea*. The fruit-stone opens by the splitting off of one or two valves on the side, according to the number of cells and seeds, and one or two seedlings may appear from one stone. The radicle emerges through the crack thus formed, and the hypocotyl elongates with or without arching, raising above ground the very characteristic fan-like plicate cotyledons, which quickly unfold; the fragments of the fruit-stone remain on or under the ground.

THE SEEDLING (Fig. 258).

Roots: primary root moderately long, becoming thick and tough in second season, terete, tapering: lateral roots numerous, moderately long, fibrous. *Hypocotyl* distinct from root, 0·4–0·9 in. long, terete or slightly compressed, cylindrical or tapering slightly upwards, green, pubescent. *Cotyledons*: petiole 0·1–0·2 in. long, flattened above, pubescent: lamina 0·4–0·6 in. by 0·6–1 in., foliaceous, reniform or sub-orbicular, broader than long, crenate, green, glabrous, palmately 5-veined, the veins prominently branched in radiate form, the branches terminating in the hollows between the crenatures, plicate along the veins, the folds persisting in fan-like form when the cotyledons expand. *Stem* erect, terete, pubescent. *Leaves* simple, alternate, exstipulate: petiole up to 0·2 in. long: lamina 0·8–5 in. by 0·4–4 in., elliptical or obovate, acute, mucronate, base acute, serrate, glabrous or sometimes slightly pubescent near the base on the under surface.

The growth of the seedling during the first season is slow, a height of 2–4 in. being attained by the end of the season even under favourable conditions. In the second season the growth is much faster; plants raised in the nursery at Dehra Dun and regularly weeded and watered attained a height of 4½ ft. by the end of the second season. The young plant has a decidedly branching habit. Regular weeding and watering have a marked effect on development. Young plants are frost-hardy, but if exposed to a hot sun they are apt to die of drought under natural conditions.

SILVICULTURAL CHARACTERS. The tree stands moderate shade. In some localities in which it occurs it stands frost well, but in the Changa Manga plantation it suffers badly. In the abnormal drought of 1907 and 1908 in the forests of Oudh it proved to be decidedly drought-resistant. It coppices and pollards well, and has good power of recovery from injury.

NATURAL REPRODUCTION. Although the fruit does not ripen until the early part of the rainy season the seeds germinate during the rainy season in which they fall. Many, however, lie ungerminated, and of these a considerable proportion are destroyed by insects, which bore through the fruit-stones and eat the seeds. A certain number lie apparently in good condition until the following rainy season, but whether or not they germinate then has not been determined. As already mentioned, the seeds are disseminated by monkeys and birds, but many fruits fall around the trees; the fleshy portion soon rots off and germinating seedlings, with their characteristic plicate cotyledons, may often be found during the rainy season. These seedlings, however, will be found to die off through drought after the rains unless they are in a comparatively moist and shady situation.

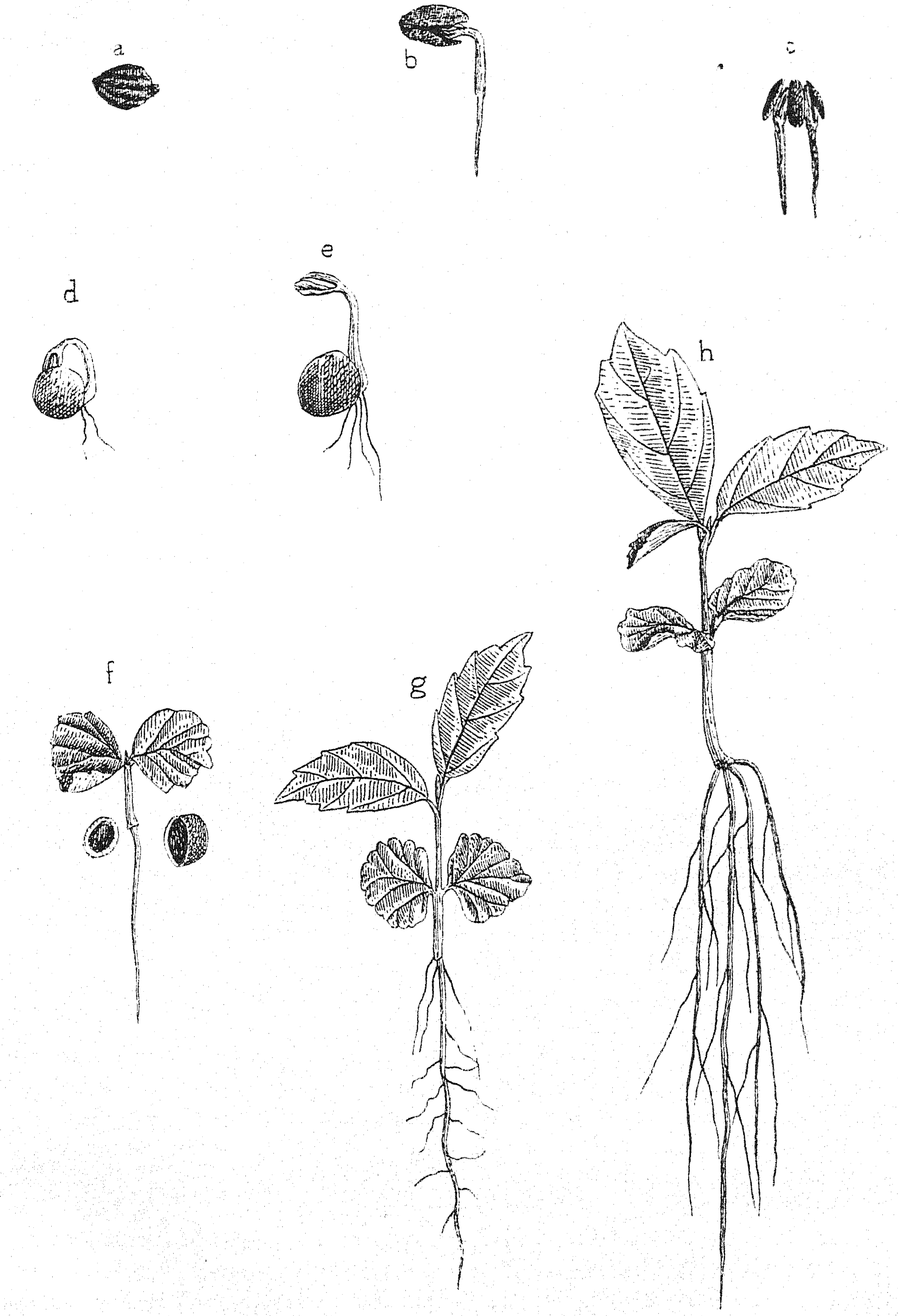

FIG. 258. *Cordia Myxa.* Seedling, $\frac{1}{1}$.

a, fruit stone ; *b–f*, germination stages ; *g, h*, early development of seedling.

Artificial reproduction. The fruit-stones should be sown in the nursery when the fruit ripens, about June–July, covered with earth and regularly watered. The seedlings begin to appear in about three to four weeks, but may continue to appear for three or four months: they should be regularly weeded and watered, and will be ready for transplanting during the following rainy season. Transplanting does not give much trouble, but it is preferable to prune down the stem to about 1 in. from ground-level and to trim off the roots to a small extent.

Rate of growth. The annual rings are sometimes but not always distinct. A cross-section in the silvicultural museum at Dehra Dun showed 51 rings for a girth of 3 ft. 9 in., representing a mean annual girth increment of 0·88 in. Brandis gives 3 to 9 rings per inch of radius, representing a mean annual girth increment of 0·7 to 2·1 in. Of specimens examined by Gamble only two showed distinct rings, of which there were 1 to 2 per inch of radius, representing a mean annual girth increment of 3·14 to 6·28 in., which is extremely fast.

The following measurements in coppice coupes at Bullawala near Dehra Dun, recorded by Mr. A. F. Broun in 1886, show the rate of growth of *Cordia* as compared with sal coppice:

Cordia Myxa: coppice measurements, Bullawala, Dehra Dun.

Age.	Mean height. *Cordia Myxa.*	Mean height. Sal.	Mean girth. *Cordia Myxa.*	Mean girth. Sal.
years.	ft.	ft.	in.	in.
8	12·5	16·2	7·2	8·3
9	13	16	12	8·6
9	13·8	13·5	10·4	8·7
10	20	11·9	24	5·9

2. **Cordia vestita,** Hook. f. and Thoms. Vern. *Kumbi, kum, kum-paiman, bairola, latora,* Hind.

A small deciduous tree with rough coriaceous leaves and a somewhat crooked bole. Bark greenish grey, smooth, with occasional deep widely separated longitudinal cracks, exfoliating in large woody scales. Wood hard, brown, streaked or mottled, very handsome, and suitable for ornamental furniture.

Distribution and habitat. Sub-Himalayan tract from the Jhelum to the Sarda, rather scattered and nowhere very common. It is often found on somewhat dry hill-sides in mixed deciduous forest, as in the Siwalik hills and the outer Himalaya, where it ascends to 4,000 ft. It is also met with on open grass-lands and in sal forest.

Leaf-shedding, flowering, and fruiting. The tree is leafless for a short time in the early part of the hot season, the new leaves appearing about April–May. The small yellowish white flowers appear from February to April and the fruits ripen in June–July. The fruit is a yellow fleshy pointed drupe about 0·5–0·7 in. long, resting in the enlarged saucer-like calyx. The pulp is sweetish and edible; it is eaten by birds, which scatter the hard fruit-stones (Fig. 259, *a*). About 80–90 fruit-stones weigh 1 oz. Fresh seed tested at Dehra Dun gave 50 per cent. of fertility, and seed from the same sample kept for a year gave 43 per cent.

FIG. 259. *Cordia vestita*—SEEDLING × $\frac{1}{2}$

a—Fruit stone, showing valve b-e—Germination stages f-i—Development of seedling during first season

GERMINATION (Fig. 259, *b–e*). Epigeous, resembling that of *C. Myxa.* The putamen splits open by the opening of a valve on one side of the stone, and through the crack thus formed the radicle descends and the characteristic fan-like plicate cotyledons, on long stalks, push their way upwards; the segments of the putamen remain in or on the ground, or one piece is carried above ground over the folded cotyledons, falling to the ground with their expansion. The young shoot subsequently appears from between the long cotyledonary petioles.

THE SEEDLING (Fig. 259).

Roots: primary root long, thick, terete, tapering, minutely tomentose: lateral roots moderate in number and length, fibrous, minutely tomentose. *Hypocotyl* distinct from root, 0·1–0·2 in. long, thick, white or green, glabrous. *Cotyledons*: petiole 0·8–1·5 in. long, flattened above, sparsely covered with minute hairs: lamina 0·7–0·9 in. by 0·9–1·5 in., foliaceous, reniform or sub-orbicular with a retuse base, broader than long, crenate, green, scabrous above, glabrous beneath, palmately 5-veined, the veins prominently branched in radiate form, the branches terminating in the hollows between the crenatures, plicate along the veins, the folds persisting in fan-like form when the cotyledons expand. *Stem* erect, terete, stiff, greenish, pubescent: internodes 0·4–1·2 in. long. *Leaves* simple, alternate, exstipulate. Petiole 0·25–0·35 in. long, channelled above, pubescent. Lamina 1·4–7 by 0·6–5 in., ovate acuminate, base acute or obtuse, serrate, dentate or entire, coriaceous, scabrous above, pubescent beneath.

The growth of the seedling during the first season is slow to moderate, but under favourable conditions it is fairly rapid in subsequent seasons. Weeding and loosening of the soil have a marked influence on the growth, which is much retarded by the presence of weeds; watering has less effect than weeding. The following measurements have been recorded in the case of seedlings raised under different conditions at Dehra Dun:

Cordia vestita: development of seedlings, Dehra Dun.

Condition under which grown.	Height at end of season. 1st season.	2nd season.	3rd season.	4th season.
(1) In nursery; weeded and watered	3–9 in.	3–5 ft.	..	..
(2) Transplants of first season not subsequently weeded or watered	Maximum 7 in.	Maximum 10½ in.	1 ft. 5 in.–1 ft. 7 in.	..
(3) Broadcast sowings, weeded but not watered	Maximum 4½ in.	Maximum 4 ft. 6 in.	6–12 ft.	Maximum 14 ft. 6 in. (girth 7 in.)

Seedlings produce a taproot which is often long and stout, a length of as much as 20 in. having been measured at the end of the first season. The season's growth ceases about November. The seedlings are leafless during January–February, and new growth starts in the end of February or during March. Seedlings are sensitive to frost, and are often killed back, but have excellent powers of recovery. They are somewhat sensitive to drought. They stand moderate shade, and even require it in a dry hot situation.

SILVICULTURAL CHARACTERS. The tree is a moderate shade-bearer. Although the seedlings are sensitive to frost the tree is hardy, and may be found persisting on grassy blanks subject to rather severe frosts where only a limited number of species are capable of surviving. It coppices well.

NATURAL REPRODUCTION. Under natural conditions the seed begins to germinate as a rule in August, and continues germinating throughout the rainy season. A certain proportion remains dormant for a year, germinating in the second rainy season. Seed which has become buried germinates much more readily than that which is lying on the surface of the ground ; the latter usually fails to germinate at all. In dry soil exposed to the sun the seedlings tend to die of drought in the dry season, and a certain amount of shade is necessary for their establishment.

ARTIFICIAL REPRODUCTION. The seed should be sown in the nursery in June or July, covered with soil and watered. The seedlings ordinarily begin to appear above ground in about two weeks, and may be transplanted during the first rainy season when about 3 to 4 in. high, though it is preferable to keep them in the nursery until the second rains, sheltering them from frost during the winter. They should be regularly weeded, the soil being kept loose ; watering should be done sparingly or not at all, but in dry hot weather shading is beneficial. When transplanting is done early in the second rainy season the size of the plants may necessitate the trimming down of the roots to some extent ; in this case either the branches should be pruned off or the whole plant should be pruned down to within about 2 in. from ground-level.

3. **Cordia Rothii,** Roem. and Sch. Vern. *Liar*, Sind ; *Gondi*, *gundi*, Hind.

A small tree of the dry parts of north-west, central, and southern India, chiefly in Rajputana, Sind, and the Deccan. The wood is hard, brown, handsomely streaked, and suitable for ornamental work. Growth, according to Gamble, 10 rings per inch of radius, giving a mean annual girth increment of 0·63 in.

4. **Cordia Macleodii,** Hook. f. and Thoms. Vern. *Dhaiman*, *dhagan*, Hind.; *Dhaiwan*, Mar.; *Hadang*, Kan.; *Godela*, Ajmer.

A moderate-sized tree of the Indian Peninsula, Rajputana, Central India, Chota Nagpur, and Orissa, in dry deciduous forests. This tree also has a handsome wood suitable for cabinet work.

2. EHRETIA, Linn.

Species 1. *E. laevis*, Roxb.; 2. *E. acuminata*, R. Br.

1. **Ehretia laevis,** Roxb. Syn. *E. floribunda*, Benth.; *E. aspera*, Roxb. Vern. *Chamror*, *koda*, Hind.; *Datrang*, Mar.; *Adak*, Kan.; *Pogadi*, Tel.; *Addula*, Tam.; *Gyaungbyu*, Burm.

A moderate-sized deciduous tree with an irregularly-shaped stem and smooth light grey to whitish bark, yellow and soft inside. Wood tough, used for agricultural implements, but as a rule little used except for fuel.

This tree is common throughout the greater part of India in deciduous forests, extending into dry regions such as Sind, the trans-Indus hills, and Rajputana. It is very common in sal forests. It occurs also in Burma.

The tree is leafless during part of February–March. The masses of small white flowers appear from February to April, and the bunches of orange-red berries, sometimes covering the tree, appear from March to June. Both in flower and in fruit the trees are a conspicuous sight.

The tree stands moderate shade. It is somewhat frost-tender, but in the

abnormal drought of 1907 and 1908 in the forests of Oudh it proved to be decidedly drought-resistant. It coppices well and produces root-suckers.

The rate of growth is slow to moderate. Measurements in sal forest sample plots in the Siwalik forest division, United Provinces, showed mean annual girth increments of 0·01, 0·07, 0·30, 0·39, and 0·57 in. Some of these obviously refer to suppressed trees. A cross-section in the silvicultural museum at Dehra Dun showed 31 rings for a girth of 2 ft. 9 in., giving a mean annual girth increment of 1·06 in. Gamble's specimens showed 5 to 8 rings per inch of radius, representing a mean annual girth increment of 0·78 to 1·26 in.

Measurements made by Mr. C. M. McCrie in 1910 in coppice coupes in the Gorakhpur district, United Provinces, showed the following results for *Ehretia laevis* as compared with sal :

Ehretia laevis : coppice measurements, Gorakhpur.

	Mean height.		Mean girth.	
Age.	*Ehretia.*	Sal.	*Ehretia.*	Sal.
years.	ft.	ft.	in.	in.
2	2·5	3	..	..
4	5·4	7	1·8	2·0
6	8·1	10·3	2·7	2·9
8	10·6	13	3·6	3·8
10	12·7	15·3	4·5	4·8
12	14·6	17·5	5·4	5·8
14	16·5	19·2	6·3	6·7
16	18·2	20·9	7·2	7·5

2. **Ehretia acuminata,** R. Br. Syn. *E. serrata,* Roxb. Vern. *Puna, punia,* Hind.; *Bual,* Ass.; *Petthin,* Burm.

A moderate-sized deciduous tree with grey longitudinally fissured bark. Wood moderately hard, used for building, agricultural implements, gun-stocks, &c. The leaves, plucked when quite young, are used for mixing with tea to make the brick-tea exported from China to Tibet, where the warmth combined with the rich red liquor produced by these leaves is said to be appreciated by the Tibetans.

The tree is local, though fairly common, in parts of the sub-Himalayan tract and outer Himalayan valleys, ascending to 5,000 ft. ; it occurs also in the Duars, Assam, Khasi and Chittagong hills, and Burma. In the sub-Himalayan tract it is often found on boulder formations and on grass-lands.

The tree is leafless in December–January, the new leaves appearing in February–March. The fragrant white flowers, in conical terminal panicles, appear in March–April, and the fruit, a small drupe, ripens in November–December.

The growth is moderate. A cross-section in the silvicultural museum at Dehra Dun showed 53 rings for a girth of 4 ft. 6 in., giving a mean annual girth increment of 1·02 in. One specimen examined by Gamble showed 7 rings per inch of radius, giving a mean annual girth increment of 0·9 in.

ORDER XLIV. BIGNONIACEAE

An order containing nine Indian genera of trees, shrubs, and climbers, many of which are remarkable for their handsome flowers; in addition there are several exotic species cultivated for ornament. The order contains some forest trees of interest yielding fair timbers. Several of the species are remarkable for the profusion with which they send up root-suckers.

Genera 1. STEREOSPERMUM, Cham.; 2. OROXYLUM, Vent.; 3. MILLINGTONIA, Linn. f.; 4. TECOMA, Juss.

1. STEREOSPERMUM, Cham.

This genus contains seven Indian species, a few of which are of some importance as accessory species. They are characterized, among other features, by their long, more or less cylindrical capsules containing a thick corky dissepiment filling up most of the capsule, along which are arranged the numerous winged seeds. The various species require further study silviculturally. The production of root-suckers appears to be a general characteristic.

Species 1. *S. suaveolens*, DC.; 2. *S. chelonoides*, DC.; 3. *S. xylocarpum*, Benth. and Hook. f.; 4. *S. neuranthum*, Kurz.

1. **Stereospermum suaveolens,** DC. Syn. *Bignonia suaveolens*, Roxb. Vern. *Padal, pandri*, Hind.; *Parul*, Mar.; *Kywèmagyolein*, Burm.

A large deciduous tree with large opposite imparipinnate leaves 1–2 ft. in length. Bark grey, exfoliating in large flat scales. Wood hard with a small yellowish brown handsomely mottled heartwood. The tree is a common and important accessory species, particularly in sal forest. It is a useful tree for reclothing bare hill-sides, as may be seen in the Siwalik hills, and for restocking grassy blanks subject to frost.

DISTRIBUTION AND HABITAT. This tree is found throughout the greater part of India in mixed deciduous and sal forests. It is common in the sub-Himalayan tract, ascending the outer hills to 4,000 ft., but is rare west of the Jumna. It occurs also in Rajputana, Chota Nagpur, Central India, and in many other parts of the Indian Peninsula, chiefly in valleys and on plateaux and plains. It is found in Upper and Lower Burma, and according to Kurz is not infrequent in the *indaing* forests of Martaban. It is probably much commoner in the sub-Himalayan tract than elsewhere, and is a constant companion of the sal; it often tends to become gregarious on clayey ground, but is by no means confined to such soil and is often found in abundance on sandy and gravelly soils. It is frequently found on grassy savannah lands. In the Siwalik hills it is characteristic of the dry upper slopes and ridges on sandstone and conglomerate, in somewhat stunted form, but reproducing freely, its chief companions being *Anogeissus latifolia, Ougeinia dalbergioides, Shorea robusta, Buchanania latifolia*, and *Pinus longifolia*.

In its natural habitat the absolute maximum shade temperature varies from 103° to 118° F., the absolute minimum from 30° to 55° F., and the normal rainfall from 30 to 150 in.

LEAF-SHEDDING, FLOWERING, AND FRUITING. In northern India the leaves turn brown and fall in March–April and the new leaves appear in May–June.

The fragrant flowers, dull purple, yellow within, in viscidly hairy panicles, appear from April to June with or before the new leaves. The fruit becomes full-sized though still unripe early in the cold season, but does not dehisce until about March to May. The fruit is a long cylindrical two-valved capsule 15–24 in. long by 0·6–0·8 in. in diameter, dark grey with raised white specks, containing a corky cylindrical dissepiment along which, in notches, the seeds are arranged. When the trees are leafless the masses of long pendent capsules give them a curious dark grey appearance. The seed (Fig. 260, *a*) is pale yellowish brown, and consists of a central bony axis 0·3–0·4 in. long with a pair of light delicate papery wings, one on either side of the axis, set somewhat obliquely like an electric fan, the whole 1–1·5 in. broad. The capsules usually dehisce on the tree, the light winged seeds escaping and being carried some distance by the wind; occasionally the capsules are blown down and dehisce on the ground. Dehiscence is gradual, and the seeds may be seen escaping a few at a time. The empty capsules often remain many months on the tree. As far as tests at Dehra Dun show, the fertility of the seed is not very high, and if kept for a year it loses its vitality almost entirely. The seeds are collected by plucking the capsules off the trees before they dehisce and placing them in the sun until they open.

Germination (Fig. 260, *b–e*). Epigeous. The radicle emerges from one end of the bony central axis of the seed; the cotyledons, enclosed in the winged seed-coat, are pushed vertically upwards by the elongation of the hypocotyl, and the seed-coat falls with the expansion of the cotyledons.

The seedling (Fig. 260).

Roots: primary root long, at first thin and delicate, afterwards thick, fleshy, and yellowish brown: lateral roots numerous, fibrous, with nodules. *Hypocotyl* distinct from root, 0·6–0·9 in. long, terete, tapering slightly upwards, green or reddish turning light brown, finely pubescent. *Cotyledons*: petiole 1–1·5 in. long, finely pubescent: lamina 0·35–0·6 in. by 0·5–0·7 in., foliaceous, somewhat fleshy, broadly ovate or orbicular, usually broader than long, retuse or cleft to about one-fourth the length, base truncate or sub-cordate, entire, minutely pubescent. *Stem* erect, terete, pubescent, with leaves crowded together and internodes up to 0·4 in. long. *Leaves* opposite, exstipulate, at first several simple, followed usually by a pair of 3-foliate, followed by 5- or 7-foliate leaves; sometimes no compound leaves appear till second season. Simple leaves sub-sessile or with petiole up to 0·5 in. long, flattened above, tomentose: leaves at first small, about 0·7 by 0·3 in. or less, becoming successively larger, up to 3·5 in. by 1·7 in. in the first season, obovate, acute, base tapering, serrate, glabrous above, pubescent or glabrescent beneath, sub-coriaceous, young leaves sometimes purplish brown.

In its early stages the seedling has a strong superficial resemblance to that of the teak, but is smooth instead of scabrous and is somewhat darker in colour. Development is ordinarily slow during the first few years, but growth is greatly stimulated by weeding. Young plants are capable of struggling well against weeds, but their development is much impeded thereby. The seedlings are drought-resistant and are fairly frost-hardy; in frosty localities they are occasionally killed back, but have good power of recovery. The leaves are somewhat brittle, and in a heavy hailstorm which occurred at Dehra Dun in 1913 the leaves of seedlings were torn to pieces, suffering more than those of most other species. The seedling produces a long and somewhat

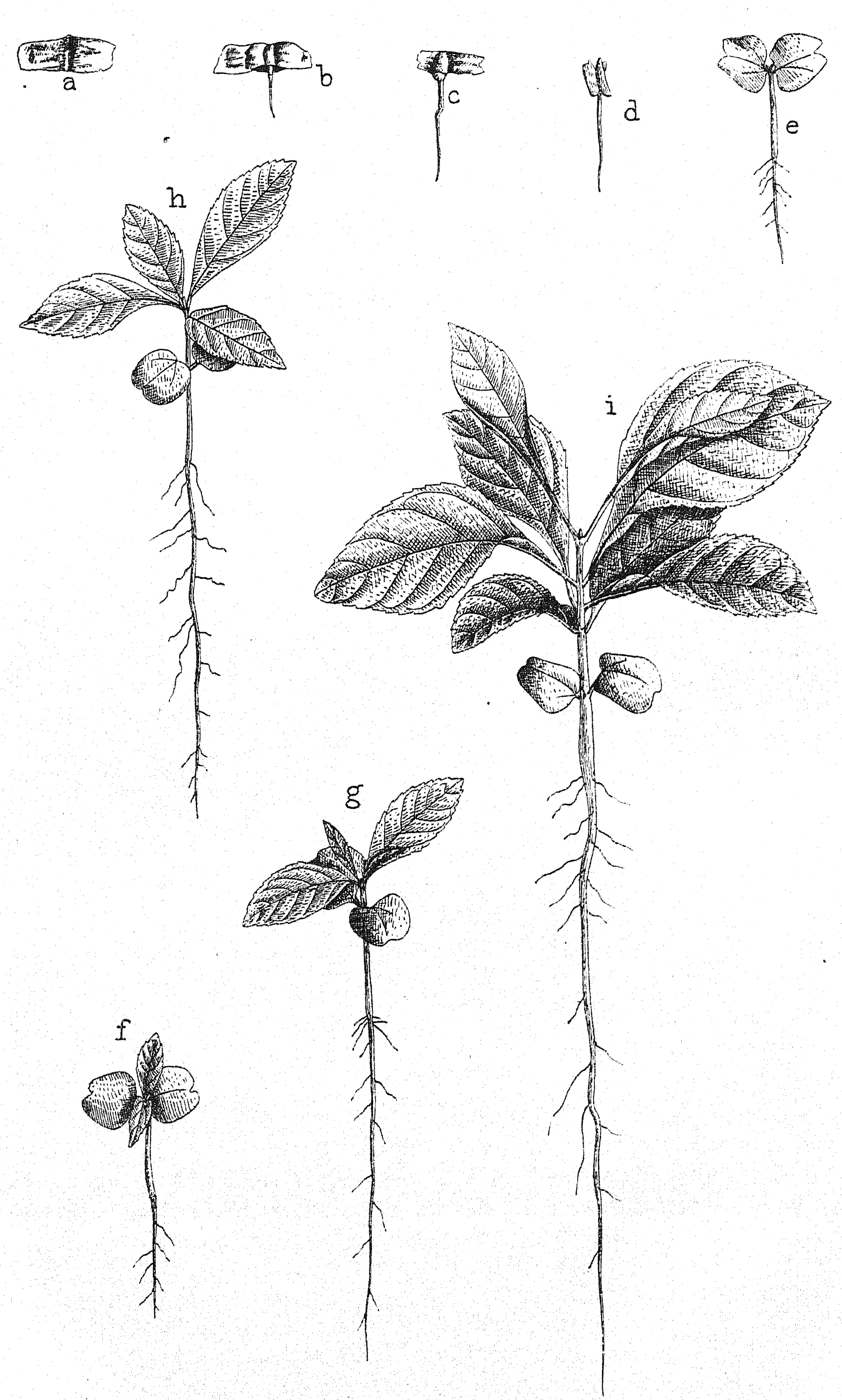

FIG. 260. *Stereospermum suaveolens.* Seedling $\times \frac{5}{8}$.
a, seed ; *b–e*, germination stages ; *f–i*, development of seedling during first season.

fragile taproot, which thickens considerably in the second year. Growth ceases about October–November, the leaves often turning reddish brown in the winter; new growth starts in April (northern India).' The following measurements of seedlings grown under different conditions at Dehra Dun, in each case in full sunlight, give some indication of the rate of growth and exhibit in a striking manner the beneficial effects of weeding:

Stereospermum suaveolens: rate of growth of seedlings under different conditions, Dehra Dun.

Condition under which grown.	Height at end of season. 1st season.	2nd season.	3rd season.	4th season.
(1) In nursery, watered and weeded	Maximum 0 ft. 2½ in.	..	..	..
(2) In nursery, watered and weeded	Maximum 0 ft. 7 in.	..	..	..
(3) Broadcast sowing, irrigated, unweeded	Maximum 0 ft. 2½ in.	Maximum 0 ft. 5 in. (dense grass and weeds)	0 ft. 2¼ in.–0 ft. 6 in. (dense grass and weeds)	..
(4) Broadcast sowing, unirrigated, unweeded	Maximum 0 ft. 3 in.	Maximum 0 ft. 5 in. (dense grass and weeds)	Maximum 0 ft. 9 in. (dense grass and weeds)	..
(5) Broadcast sowing, unirrigated, weeded	Maximum 0 ft. 3½ in.	Maximum 1 ft. 6 in. (vigorous)	0 ft. 7 in.–6 ft. 0 in. (larger plants vigorous, suppressing the smaller ones)	Maximum 11 ft. (maximum girth 6 in.; dominant stems vigorous, suppressing the smaller ones)

SILVICULTURAL CHARACTERS. The tree is a moderate light-demander. It resists fire well, and young plants have good power of recovery when burnt back. It is not readily browsed by cattle or goats, but is not entirely immune from damage by browsing. It is decidedly frost-hardy, and in the sub-Himalayan tract is often one of the few trees capable of surviving on grassy blanks subject to frost: in the severe frost of 1905 it escaped injury entirely in some localities, but suffered to some extent in others. In the abnormal drought of 1907 and 1908 in the forests of Oudh it proved to be conspicuously hardy. It produces suckers from lateral roots, these roots being often of considerable thickness.

NATURAL REPRODUCTION. Under natural conditions germination begins early in the rainy season and continues for some time during that season. Various circumstances favour the reproduction of this species; the seed falls for the most part after the fire season, while the seedlings are hardy, are not readily browsed, have good power of recovery from damage by fire or other injury, and persist well in a growth of grass and weeds if these are not excessively dense. Natural reproduction of seedlings and suckers is often abundant in unpromising situations such as dry exposed hill-sides. As in the case of many species with winged seeds, natural reproduction often springs up readily on land which has been ploughed up for cultivation.

ARTIFICIAL REPRODUCTION. Weeded line sowings as well as transplanting from the nursery can be carried out successfully. For nursery purposes fresh seed should be sown about April–May, preferably in light porous sandy soil, covered lightly and watered: the seedlings ordinarily begin to appear in about

two weeks and should be regularly weeded and somewhat sparingly watered. Transplanting with entire roots is difficult except during the first rainy season while the plants are still small, and even then care is necessary. Complete success has been attained at Dehra Dun by transplanting during the second rainy season after pruning the stem down to about an inch from ground-level and trimming the roots down to a length of about 9 in.

RATE OF GROWTH. The following results of girth measurements in high forest sample plots are available:

Stereospermum suaveolens: rate of growth in high forest sample plots.

Province.	Forest division.	Locality.	Number of years under measurement.	Number of trees under measurement.	Girth classes.	Mean annual girth increment for period.
					ft.	in.
United Provinces	Saharanpur	Lakarkot and Malowala	6 and 12	2	0–1	0·52
				2	1–2	0·52
				2	2–3	0·43
				1	3–4	0·63
	Lansdowne	Andhermajheri	17	10	1½–4	0·25
		Jogichaur	4 and 12	14	1½–4	0·28
		Kauria	4 and 5	3	1½–3	0·24
		Gewain	12	2	1½–3	0·31
	Ramnagar	Rehar	19	15	1½–3	0·20
	S. Kheri	Kishanpur	9	1	2–3	0·22
				3	3–4	0·20
				1	4–5	0·15
Central Provinces	Balaghat	Raigarh and Baihar	8	23	1–2	0·17
				2	2–3	0·18

These figures indicate a comparatively slow rate of growth. A cross-section in the silvicultural museum at Dehra Dun showed 53 rings for a girth of 5 ft., giving a mean annual girth increment of 1·13 in.

Coppice measurements made in 1886 by Mr. A. F. Broun at Bullawala near Dehra Dun gave the following results for *Stereospermum suaveolens* as compared with sal:

Stereospermum suaveolens: coppice measurements, Bullawala, Dehra Dun.

Age.	Mean height.		Mean girth.	
	Stereospermum.	Sal.	*Stereospermum.*	Sal.
years.	ft.	ft.	in.	in.
8	20	13·2	9·0	7·1
10	17	11·9	9·0	5·9

Measurements made in 1910 by Mr. C. M. McCrie in coppice coupes in the Gorakhpur district, United Provinces, gave the following results:

Stereospermum suaveolens: coppice measurements, Gorakhpur.

Age.	Mean height.		Age.	Mean height.	
	Stereospermum.	Sal.		*Stereospermum.*	Sal.
years.	ft.	ft.	years.	ft.	ft.
2	3·0	3·0	10	8·3	15·3
4	5·0	7·0	12	9·0	17·5
6	6·5	10·3	14	9·6	19·2
8	7·4	13·0	16	10·0	20·9

2. **Stereospermum chelonoides**, DC. Vern. *Padri, pader, para,* Hind.; *Padal,* Mar.; *Mukarti,* Kan.; *Padri,* Tam.; *Thakutpo,* Burm.

A large deciduous straight-stemmed tree, in unfavourable situations a small tree, with imparipinnate leaves clustered towards the ends of the branchlets. Bark grey to brown, fairly smooth. Wood hard, grey, used for building, furniture, tea-boxes, canoes, &c.

Distribution and habitat. Sub-Himalayan tract from Oudh (Gonda forests, not common) eastward to Assam, common up to 2,000 ft. in the eastern Himalaya, Chittagong, throughout Burma in mixed deciduous forests, ascending to 4,000 ft. in the Shan hills ; the Indian Peninsula, chiefly on the western side, rare in Chota Nagpur and Orissa, fairly common in valleys in the Central Provinces, in Bombay chiefly in the moist forests of the Konkan and North Kanara ; common in the deciduous forests of Travancore up to 4,000 ft. (Bourdillon).

This tree does not extend to such dry regions as *S. suaveolens*. In its natural habitat the absolute maximum shade temperature varies from under 100° to 115° F., the absolute minimum from 35° to over 60° F., and the normal rainfall from 40 to 150 in.

Leaf-shedding, flowering, and fruiting. The leaves are shed about February–March, the new leaves appearing in April. The fragrant flowers, yellow marked with red, in lax drooping panicles, appear before, with, or after the new leaves from April to June. The fruits ripen in the following cold season ; the time of their dehiscence has not been accurately recorded. The capsules are slender, 10–30 in. long by 0·25–0·5 in. in diameter, with a thick septum in the deep notches of which the seeds lie ; the seeds are wedge-shaped and winged, about 1·25 in. broad with the wings.

Silvicultural characters. The silvicultural characters of this tree require study. It produces root-suckers freely and coppices well. It is probably less hardy than *S. suaveolens*.

Rate of growth. Gamble's specimens averaged 7 rings per inch of radius, giving a mean annual girth increment of 0·9 in.

3. **Stereospermum xylocarpum,** Benth. and Hook. f. Syn. *Bignonia xylocarpa*, Roxb. ; *Spathodea xylocarpa*, T. And. Vern. *Paral*, C. P. ; *Kharsing*, Mar. ; *Genasing*, Kan.

A moderate-sized to large deciduous tree with very large bi- or tripinnate leaves up to 4 ft. long. Bark light grey, fairly smooth, flaky. Wood hard, tough, and elastic, with a small orange-brown heartwood, used for cart-shafts and cabinet work.

This is a tree of the Indian Peninsula in deciduous forests of the Central Provinces, Bombay from Khandesh southwards, and Madras southwards to Travancore. It is leafless for a short time in the hot season. The large fragrant white or pinkish flowers appear in April–May and the capsules ripen next hot season. The latter are conspicuous from their large size, being sometimes as much as 3 ft. in length, woody and tubercled, with a central septum about 0·5 in. thick. The winged seeds are about 1·25 in. broad.

The silviculture of this tree requires study. It is a light-demander, though it stands some shade in youth : it produces root-suckers. Bourdillon gives the rate of growth as about 9 rings per inch of radius, or a mean annual girth increment of 0·7 in.

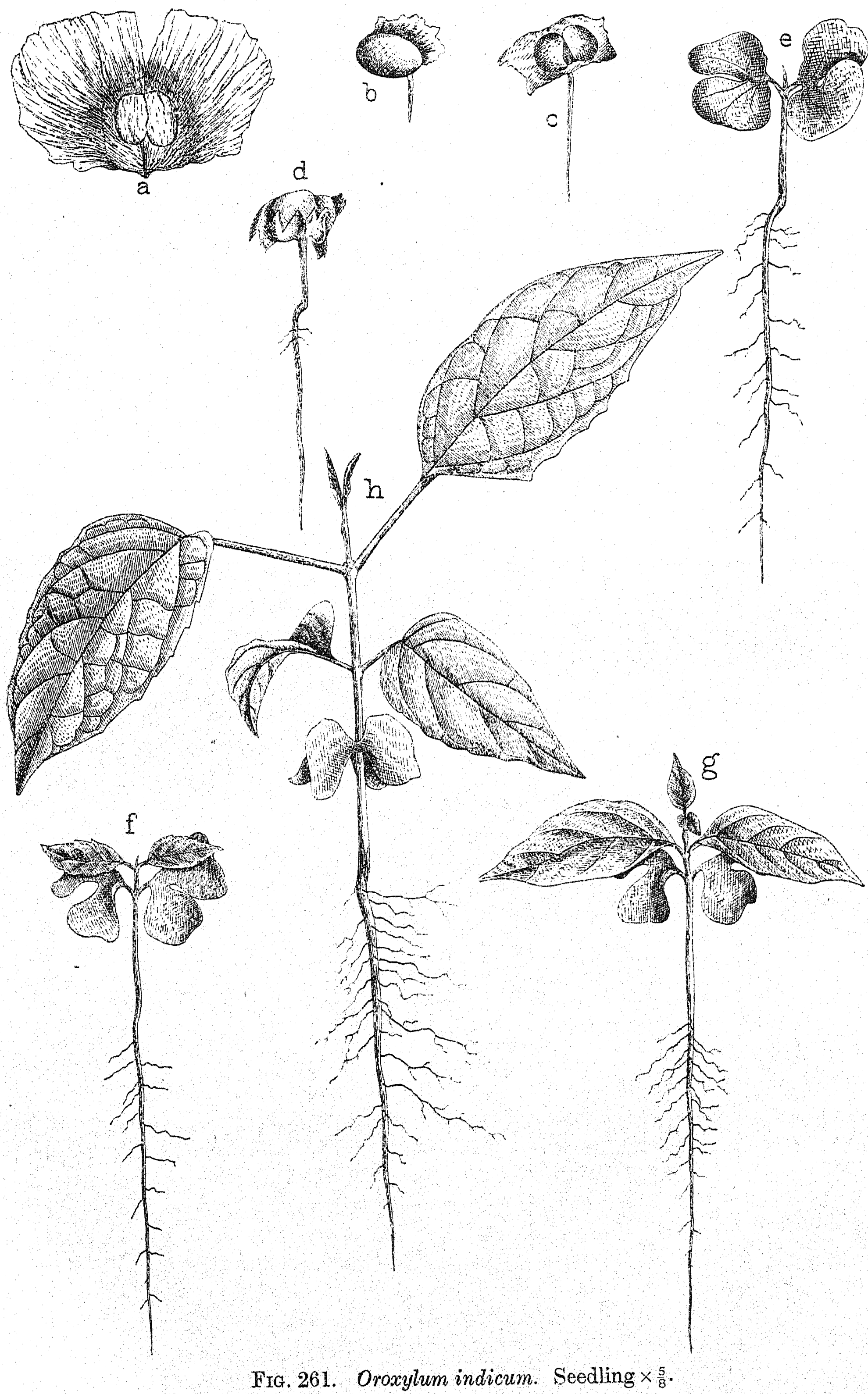

FIG. 261. *Oroxylum indicum.* Seedling $\times \frac{5}{8}$.

a, winged seed ; *b–e,* germination stages (wing of seed almost wholly removed) ; *f–h,* development of seedling during first season.

4. **Stereospermum neuranthum,** Kurz. Vern. *Thandè*, Burm.

A deciduous tree of the mixed deciduous forests of Burma. It is fairly common both in the upper and in the lower mixed types. It produces root-suckers. The wood is hard and of very fair quality.

2. OROXYLUM, Vent.

Oroxylum indicum, Vent. Syn. *Calosanthes indica*, Bl. Vern. *Pharrái, ullu, sauna*, Hind.; *Tetu*, Mar.; *Pana*, Tam.; *Kyaungya*, Burm.

A small deciduous tree with few branches and very large opposite compound leaves 3–5 ft. long, tripinnate near the base, bipinnate in the centre, and once pinnate towards the apex: when leafless the branches are easily recognized from the large opposite leaf-scars. Bark light greyish brown, soft. Wood yellowish white, soft, not used; bark used for tanning and dyeing. The tree is a conspicuous one in the forests of India, especially when leafless and bearing its large scabbard-like capsules.

Distribution and habitat. Throughout the greater part of India and Burma except in the driest regions, chiefly in deciduous forests, but sometimes scattered in evergreen forest, and often in ravines and other moist places; also in the Andamans and Ceylon. In the sub-Himalayan tract it ascends to 3,500 ft.; it is rare west of the Jumna.

Leaf-shedding, flowering, and fruiting. The leaves usually turn a dark coppery brown in the cold season, falling from December to February; the new leaves do not appear till May–June. The large fleshy purplish but not handsome flowers, in stout terminal racemes, appear from May to August; the fruits develop rapidly, attaining full size by the beginning of the cold season and dehiscing usually from February to May. The fruit is a large conspicuous two-valved flat woody capsule 1–3 ft. long and 2–3·5 in. wide, containing a large number of seeds. The seeds (Fig. 261, *a*) are flat and are surrounded by a thin transparent white papery wing, the whole 2–2·7 in. across; the testa is thin, delicate, and membraneous, enclosing a light green flat embryo 0·5 in. in diameter faintly visible from the outside. About 280–340 seeds weigh 1 oz.; they are carried by wind to some distance from the tree. If carefully stored the seed retains its vitality for at least a year, a sample kept for a year and tested at Dehra Dun showing 95 per cent. of success. If exposed to moisture or other adverse conditions, however, the seed becomes rapidly spoiled.

Germination (Fig. 261, *b–e*). Epigeous. The soft delicate testa, resembling a thin layer of pith and capable of absorbing and retaining moisture during germination, together with the membraneous wing, usually rots off in part or becomes partly washed off by rain during germination. The radicle emerges first, the hypocotyl then elongating and carrying above ground the large leafy bifid cotyledons, which soon expand, the remains of the testa being either left in or on the ground or carried up, dropping with the expansion of the cotyledons.

The seedling (Fig. 261).

Roots: primary root long, thick, terete, tapering, whitish: lateral roots fairly numerous, fibrous, distributed down main root. *Hypocotyl* distinct from root, 0·9–1·1 in. long, somewhat compressed, tapering slightly upwards,

green, minutely pubescent. *Cotyledons*: petiole 0·2–0·25 in. long, channelled above, minutely pubescent: lamina 0·6–0·8 in. by 1·2–1·5 in., foliaceous, much broader than long, deeply bifid, lobes reniform and sometimes partly overlapping each other, entire, minutely pubescent above, glabrous beneath; each lobe with three principal veins from the base, subsidiary veins reticulate. *Stem* erect, slightly compressed; glabrous or young parts minutely pubescent; internodes up to 1 in. long in younger stages. *Leaves* opposite, exstipulate, first few pairs simple, followed by one or more pairs of 3-foliate leaves, and then by 5-foliate leaves, which are usually produced in the second season. Simple leaves with petiole 0·5–2 in. long, glabrous, channelled above: lamina 2–4 in. by 1·3–2 in., ovate acuminate, entire or dentate, base often decurrent, glabrous, or veins on lower surface minutely pubescent; venation arcuate reticulate, veins depressed on upper surface and prominent beneath.

The growth of the seedling is slow to moderate, maximum heights of about 6 in., 1 ft., and 2½ ft. being attained by the end of the first three seasons if no weeding or watering is done, and nearly double these dimensions being attained if the plants are weeded and watered. Young seedlings are sensitive to frost and to drought, many dying off in the hot season in dry situations exposed to the sun; they benefit by moderate shade and moisture. The leaves of seedlings turn reddish brown in the cold season, falling in December–January, after which the seedlings are leafless until March, when new growth commences (northern India).

Silvicultural characters. The tree stands moderate but not heavy shade. Its root-system is superficial, and it produces root-suckers in great profusion, these often forming a dense growth round the parent stem.

Natural reproduction. Under natural conditions the seed germinates early in the rainy season. For successful reproduction a certain amount of shade and moisture appears to be necessary in the early stages, owing to the tendency of the seedlings to die of drought in hot exposed situations. Otherwise seedlings have good power of making their way through a moderate growth of grass and weeds.

Artificial reproduction. Nursery-raised seedlings can be transplanted without difficulty during the first and second rainy seasons. The seed should be sown in the nursery in March or April, and lightly covered with earth, the beds being regularly watered, slightly shaded, and protected from frost in winter. The tree may also be propagated by transplanting root-suckers.

Rate of growth. Gamble's specimens gave 2½ to 4 rings per inch of radius, or a mean annual girth increment of 1·57 to 2·52 in., which is fast.

3. MILLINGTONIA, Linn. f.

Millingtonia hortensis, Linn. f. Syn. *Bignonia suberosa*, Roxb. Indian cork-tree. Vern. *Akás nim*, Hind.; *Kat malli*, Tam.; *Kavuki*, Tel.; *Egayit*, Burm.

A tall, handsome tree, with an elongated crown and large bipinnate, sometimes tripinnate leaves. Bark dark yellowish grey, corky. Wood soft, yellowish white, of very fair quality, suitable for tea-boxes and similar purposes. The tree is believed to be indigenous in Burma, and is largely cultivated for ornament throughout India. It is fast-growing, tall, and straight, and, as Gamble rightly suggests, it is well worth considering as a useful soft-wood for

plantation purposes, though it does not appear to have been tried as such. In October–November (northern India) it is covered with drooping masses of very fragrant white to pale pink flowers with long slender corolla-tubes, which perfume the air around. The fruit, a flat linear capsule, about 1 ft. long with numerous delicately winged seeds, ripens towards the end of the hot season ; seeds are rarely produced in northern India.

The tree is decidedly hardy, and is not particular as to soil ; although it grows best in a moist climate it does fairly well in dry situations, growing well in Lahore Cantonment without irrigation, which not many trees are capable of doing. It is, however, brittle and shallow-rooted, and is liable to be broken or uprooted by strong winds. It has a tendency to send up root-suckers in great profusion, which is a disadvantage in gardens. It is easily raised from seed when obtainable, from cuttings put down in the spring, or from root-suckers dug up and transplanted during the rainy season. Seed should be sown in the nursery as soon as it ripens, towards the end of the hot season, and the seedlings, which bear transplanting well, should be planted out a year later at the beginning of the rainy season.

The growth is fast. Gamble's specimens gave four to five rings per inch of radius, representing a mean annual girth increment of 1·26 to 1·57 in.

4. TECOMA, Juss.

Tecoma undulata, G. Don. Syn. *Tecomella undulata*, Seem. Vern. *Lahura*, Punj. ; *Lohero*, Sind ; *Raktarohida*, Mar. ; *Rori*, Bal.

A shrub or small tree, nearly evergreen, with simple grey leaves and large yellow to orange flowers, which appear from January to April, when the tree is a very handsome sight. The fruit, a curved capsule 6–8 in. long, ripens from May to July. The wood is yellowish brown, mottled, handsome, highly prized for furniture, carving, and agricultural implements (Brandis).

This is a tree of the driest regions of India, namely the Suliman and Salt Ranges, Sind, Baluchistan, trans-Indus, Punjab, ascending to 4,000 ft. in the outer Himalaya, Rajputana, Guzerat, and Khandesh. It is sometimes planted in gardens. It coppices fairly well, and is easily grown from seed or cuttings. It is readily browsed by cattle. It is drought-hardy and very resistant to fire. It would be a useful species for afforesting dry tracts.

ORDER XLV. ACANTHACEAE

This order, consisting chiefly of herbaceous plants, contains some undergrowth shrubs and climbers of indirect importance in Indian forestry.

Genera 1. Acanthus, Linn. ; 2. Adhatoda, Nees ; 3. Phlogacanthus, Nees ; 4. Strobilanthes, Bl.

1. ACANTHUS, Linn.

Acanthus ilicifolius, Linn.

A spinescent shrub of the mangrove forests where it sometimes forms a dense undergrowth troublesome in wood-cutting operations.

2. ADHATODA, Nees.

Adhatoda Vasica, Nees. Syn. *Justicia Adhatoda,* Linn.

A gregarious shrub, abundant in the sub-Himalayan tract, and ascending the outer hills to 4,000 ft. It appears in great quantity on waste places, where it persists and spreads owing to its immunity from damage by browsing. It also forms a dense undergrowth in riverain forests of *Acacia Catechu* and *Dalbergia Sissoo,* and sometimes also in mixed deciduous forests.

3. PHLOGACANTHUS, Nees.

Phlogacanthus thyrsiflorus, Nees.

An evergreen shrub with a large thyrsoid inflorescence of handsome brick-red flowers, frequent as an undergrowth species in moist, shady places in parts of the sub-Himalayan tract and in Burma.

4. STROBILANTHES, Blume.

This genus contains about 160 species of handsome flowering shrubs, many of which are of great importance in Indian forestry as undergrowth species. The majority are shade-bearing, and many are gregarious, forming dense masses over considerable areas and having an important bearing on the natural reproduction of trees. Although several species flower and fruit annually, many, like bamboos, flower and fruit at intervals of several years, the interval between successive flowerings being as a rule constant for each species, but varying with different species. After the flowering and fruiting the whole plant dies, and the following year the ground is covered with young seedlings commencing the next generation; this periodic dying is of importance, as will be seen below, in connexion with silvicultural operations for the eradication of the plant. When gregarious flowering takes place, bees are attracted in large numbers, while R. M., writing in the *Indian Forester,* vol. xx (1894), p. 130, remarks on the large number of jungle-fowl which were attracted by the seed during a gregarious seeding in the Nilgiris. An interesting general account of the more important Indian species is given in Gamble's *Manual of Indian Timbers* (1902), pp. 518 et seq., which may be referred to. See also *Indian Forester,* vol. xiv (1888), p. 153. The members of this genus are characteristic mainly of hilly country, the most notable exception being *S. auriculatus,* Nees, a common plant in the sal forests of the sub-Himalayan tract and the Indian Peninsula.

In no part of India is this genus so well represented as in the Nilgiris and other hills of southern India, where the plants reach a larger size than elsewhere and are found in profusion, with great variety and beauty of flowering, in the *shola* forests. *S. foliosus,* T. And., is one of the largest species, the stems attaining 4–6 in. diameter. Perhaps the commonest and best known species of the Nilgiris is *S. Kunthianus,* T. And., which prefers dry slopes on the eastern sides of the hills where there is little or no tree forest; this species flowers at intervals of four to six years, giving a bright blue colour to the landscape. The genus is also well represented in the Himalaya and the hilly parts of Assam, Burma, and the Indian Peninsula.

In the eastern Himalaya, among the commonest species are *S. pectinatus,*

T. And., and *S. divaricatus*, T. And. The former is a large shrub, attaining a height of 10 ft. and a girth of 9 in. or sometimes more ; its flowering period is twelve years (recorded 1890, 1902). In the western Himalaya, *S. alatus*, Nees, and *S. Dalhousianus*, Clarke, are common non-gregarious species of little silvicultural importance, which flower every year. The important species of this region is *S. Wallichii*, Nees (with *S. atropurpureus*, Nees, which is possibly not a distinct species). This plant, known in Jaunsar as *jhanu*, grows gregariously, forming a dense carpet in the oak and fir woods at 7,000–10,000 ft., and preventing by its thick mass of roots and stems the establishment of natural reproduction of tree species ; the results of experiments in eradicating it are described below. This plant flowers and dies at intervals of twelve years (recorded 1882, 1894, 1906, 1918). Its mode of growth is peculiar, though possibly that of other species may be similar. Each year a new shoot consisting of several internodes is sent up in the spring, but at the end of the season the whole of the year's shoot drops off except the lowest internode of the year, so that the age of a plant can at any time be told by counting the number of old internodes.

In the Western Ghats from Bombay southwards there are several important species. Talbot enumerates thirteen species in the Bombay Presidency, of which one, *S. callosus*, Nees, is common on laterite or hard rocky ground, and extends to comparatively dry trap regions of the Satpuras in Khandesh and Central India. This species, known in Bombay as *karvi*, flowers at intervals of seven or eight years ; its stems are used with mud plaster for walls of huts, and when it flowers and dies the dry stems are largely collected for fuel. Of other gregarious species of the Western Ghats, which are said to flower at intervals of about seven years, may be mentioned *S. reticulatus*, Stapf (vern. *akra*), *S. barbatus*, Nees, *S. sessilis*, Nees (flowers every seven or fifteen years ?), and *S. perfoliatus*, T. And.

In Burma there are species which form a dense undergrowth in teak forests, hindering reproduction. Mr. C. W. A. Bruce [1] describes the gregarious flowering of *S. rufescens* in the teak forests of the Upper Chindwin district. This plant is said to flower once in six years, when it clothes the forest undergrowth with masses of strongly-smelling blue flowers which attract innumerable bees ; the flowering was observed in March, the plants seeded early in April, and the dead stems acted as a protection against fire, no doubt because they had killed out the grass and weeds and were themselves less inflammable than these.

The silvicultural importance of the gregarious members of this genus lies in their effect on the natural reproduction of tree species, and it will be useful to consider the results of efforts made to eradicate them. It does not always follow, however, that it is necessary or even advisable to eradicate the plant, for, in the case of the larger species at all events, it may afford a useful shelter to shade-bearing tree species in early youth, and its eradication may result in the entry of weeds of a more noxious description. The eradication of *S. Wallichii*, Nees, has been carried out experimentally from time to time at Deoban, near Chakrata, in the western Himalaya, where it exists as a dense carpet under *Quercus semecarpifolia*, and prevents seedlings of that species

[1] Ind. Forester, xxi (1895), p. 47.

and of firs from establishing themselves. Mere uprooting of the shrub has given satisfactory results, but the cost amounted to over Rs. 6 per acre. Also since there are often tree seedlings among the *Strobilanthes* these stand in danger of being uprooted during the process. Advantage was therefore taken of the gregarious flowering of 1906 to ascertain if the cutting of the flowering or fruiting stems would have any effect. The flowers began to appear in the first week of July, the seed ripened from the middle of September to the middle of October, and the plants died by the first week in November. The cutting of the flowering shoots was commenced in the middle of July, but this was found to be ineffectual, as new flowering shoots were produced, and cutting had to be repeated two or three times. It was found eventually that the best time to cut the stems was immediately before the seed ripened, that is, in September. An experimental plot was kept under observation for six years subsequently, and during this time no *Strobilanthes* seedlings appeared, while numerous oak seedlings succeeded in establishing themselves. Many oak seedlings were found to date from the time when the *Strobilanthes* was eradicated, but many on the other hand were older, which indicates that the oak seedlings were able to persist in spite of the dense covering of *Strobilanthes*, though they were assisted greatly by its removal.

Outside this plot the *Strobilanthes* was observed to commence germination in the first week of September of the year following the seeding, and within a year or two the ground was again carpeted with seedlings. The plant is a favourite fodder of sheep, goats, and buffaloes, and it was suggested that the admission of grazing before the fruit ripened would have the same effect as cutting; the owners of the animals, however, refused to allow them to graze, on the ground that the unripe fruits are injurious, although after the seed ripened they ate the fruits readily without harm. There can be little doubt that even without artificial measures for eradicating *Strobilanthes*, natural reproduction of tree species benefits greatly each time the plant dies naturally, for it takes two or three years at least for the new generation to reach a size large enough to be troublesome.

Mr. B. B. Osmaston [1] mentions that in the case of *S. pectinatus*, T. And., a large shrubby species in the Darjeeling hills, an experiment made during the gregarious flowering of 1902 showed that it could be eradicated successfully if cut in the month of June, when it had commenced to flower; in this it differs from *S. Wallichii*.

Mr. J. S. Gamble [2] has described the measures taken in the eradication of *Strobilanthes* in the Nilgiris, and the following passage may be quoted:

'So dense is the thicket of *Strobilanthes* in the undergrowth of the forests, that under ordinary natural circumstances it is really only at the time of the periodical flowerings that the tree seedlings get a chance of a start. There are usually thousands to be found under the thicket, but until the *Strobilanthes* dies, or is cut away, they simply remain stunted, waiting until the removal of the cover gives them a chance, and then they usually take advantage of it and come on quickly. It has, consequently, on the Nilgiris been lately found useful to assist in disengaging the seedlings by clearing away the growth of *Strobilanthes*. In the forests round Ootacamund and Coonoor, where there is a large demand by the poorer classes of natives for small fuel, and where the

[1] Ind. Forester, xxx (1904), p. 195.

[2] *Ibid.*, xiv (1888), p. 154.

hard, brightly burning wood of the *Strobilanthes* is much appreciated, it is possible to clear away the growth of it and not only allow of the young tree seedlings getting a chance of growing, but provide a considerable amount of fuel ample, at very cheap rates, to cover the whole cost of the work. In the Lamb's Rock forest, 37 acres cleaned in 1886, at a cost of Rs. 222, produced 9,038 head-loads of fuel (about 323 tons), realizing at one anna each, Rs. 565, equivalent to a net profit of Rs. 9–4–0 per acre. Something like nine-tenths of the material cut consisted of *Strobilanthes*. The good results of this work were most marked: myriads of seedlings were disengaged, and a few years hence, with the help of a seed cutting or cutting under selection in the cover, what was a few years ago merely a dilapidated *shola* with cover of old, mostly unsound, trees and underwood of *Strobilanthes*, will be converted into a fully stocked pole forest. It may easily be understood that the clearing of *Strobilanthes* must precede the seed cutting or the cutting under selection (*jardinage*). When the cover overhead in a forest is light, the bank of *Strobilanthes* underneath is often very valuable as assisting to retain the moisture in the soil, prevent fires, and nurse the tree seedlings, and in some cases it is best not to clear away the growth too wholesale, but to disengage seedlings in plots where they are found sufficiently thick and good. An example of a *shola* in which not only the *Strobilanthes* were cut, but also the covering trees some years ago, may be seen in the valley at the back of the inspection house at Naduvatam. There, the growth of new *Strobilanthes* and tree seedlings together is so thick as to be at the disadvantage of the latter; and, did funds admit, the *Strobilanthes* should now be thinned out.'

ORDER XLVI. VERBENACEAE

The chief importance of this order lies in the fact that it contains the principal timber tree of India, and one of the most important in the world, namely the teak, *Tectona grandis*, Linn. f. It contains also other trees of some importance or interest (*Gmelina*, *Vitex*, *Premna*), as well as numerous shrubs and several climbers.

Genera 1. TECTONA, Linn. f.; 2. GMELINA, Linn.; 3. VITEX, Linn.; 4. PREMNA, Linn.; 5. CALLICARPA, Linn.; 6. AVICENNIA, Linn.; 7. LANTANA, Linn.

1. TECTONA, Linn. f.

Species 1. *T. grandis*, Linn. f.; 2. *T. Hamiltoniana*, Wall.

1. **Tectona grandis**, Linn. f. Teak. Vern. *Ságun*, Hind.; *Ságwan*, *ság*, Mar.; *Tegu*, *tegina*, Kan.; *Teku*, Tel.; *Thekku*, Tam., Mal.; *Kyun*, Burm. (Fig. 262.)

A large deciduous tree with a rounded crown and, under favourable conditions, a tall clean cylindrical bole, which is often buttressed at the base and sometimes fluted. Branchlets quadrangular, channelled, with a large quadrangular pith. Leaves opposite, large, broadly elliptical or obovate, usually 1–2 ft. long, but often larger in coppice-shoots and young plants, rough above, stellately grey tomentose beneath, with minute glandular dots, which are red in young leaves, afterwards turning black. Bark, 0·15–0·7 in. thick, grey or light greyish brown, fibrous, with shallow longitudinal fissures, exfoliating in long, thin, narrow somewhat corky flakes.

Measurements of bark thickness in various localities in Bombay and the Central Provinces showed averages of 0·15 to 0·4 in. for trees of small to

moderate size, and gave a general average of about 0·25 in. Measurements in the Nilambur plantations gave the following average bark thicknesses :

Girth of tree,	1–2 ft. ;	bark thickness,	0·5 in.
,, ,, ,,	2–3 ft. ;	,, ,,	0·55 in.
,, ,, ,,	3–4 ft. ;	,, ,,	0·65 in.
,, ,, ,,	4–6 ft. ;	,, ,,	0·7 in.

Wood moderately hard. Sapwood small, whitish. Heartwood dark golden yellow, sometimes with dark streaks, turning brown with age, oily, with a characteristic odour, extremely durable, seasons well, and does not warp or split.

The teak is the most important timber tree of India. For ship-building, its timber stands in a class by itself, and has a world-wide reputation. It is also extensively used for house-building, bridge and wharf construction, piles, furniture and cabinet-work, railway carriages and wagons, carving, ordnance work, wheel spokes and felloes, general carpentry, and numerous other purposes. Teak timber is largely exported from Burma to Europe.

Under favourable conditions the teak reaches large dimensions. Bourdillon[1] records a tree in the Achencoil valley, Travancore, 26 ft. in circumference, but it had a short bole ; he mentions that at the beginning of last century, when the British Naval Department were collecting teak in Travancore, a tree was felled in the Idiyera valley which measured 7 ft. in diameter at its butt and 26 in. at a length of 70 ft., and therefore contained 900 cubic ft. of timber. In the Anamalais Beddome records trees above 22 ft. in girth, with boles 80 or 90 ft. to the first branch. Mr. K. R. Venkatramana Iyer[2] records an exceptionally tall tree standing in evergreen forest near the Karumpoya river in the Edakutti forest, South Malabar ; it had a height of 192 ft., a clean straight trunk to the first branch of 114 ft., and a girth at base of 16 ft. 8 in., and at $4\frac{1}{2}$ ft. from ground-level of 15 ft. 10 in. Mr. H. Tireman[3] records a tree felled in the forests of southern Coorg which had a girth at breast-height of 25 ft. 2 in., and yielded three logs with the following measurements :

(1)	Length 11 ft. 7 in. ;	mean girth 18 ft. 6 in. ;	out-turn 248 cubic ft.
(2)	,, 11 ft. 4 in. ;	,, ,, 16 ft. 1 in. ;	,, 182 ,, ,,
(3)	,, 10 ft. 3 in. ;	,, ,, 14 ft. 4 in. ;	,, 132 ,, ,,
		Total	562 ,, ,,

Muhammed Habibullah Sahib[4] records a tree felled in the Tekkadi leased forests, South Coimbatore. The girth at breast-height was 18 ft. 7 in., and the tree yielded eleven logs totalling 711 cub. ft. Mr. A. Wimbush[5] records a tree recently felled at Palacadava in South Coimbatore which yielded five logs totalling 1,099 cub. ft.

Among large trees recorded from Burma may be mentioned one measured by Dr. Brandis in the Gwethe forest, Toungoo, with a girth of 16 ft. at 6 ft. from ground-level, and a clear bole to the first branch of 114 ft. A tree 19 ft. in girth at 6 ft. from ground-level is recorded in the working plan of the Kadinbilin forest, Tharrawaddy, 1885. In the Myittha-Panlaung forest, Mr. H.

[1] Forest Trees of Travancore, p. 285.
[2] Ind. Forester, xxxix (1913), p. 174.
[3] *Ibid.*, xliv (1918), p. 86.
[4] *Ibid.*, p. 468.
[5] *Ibid.*, xlvi (1920), p. 247.

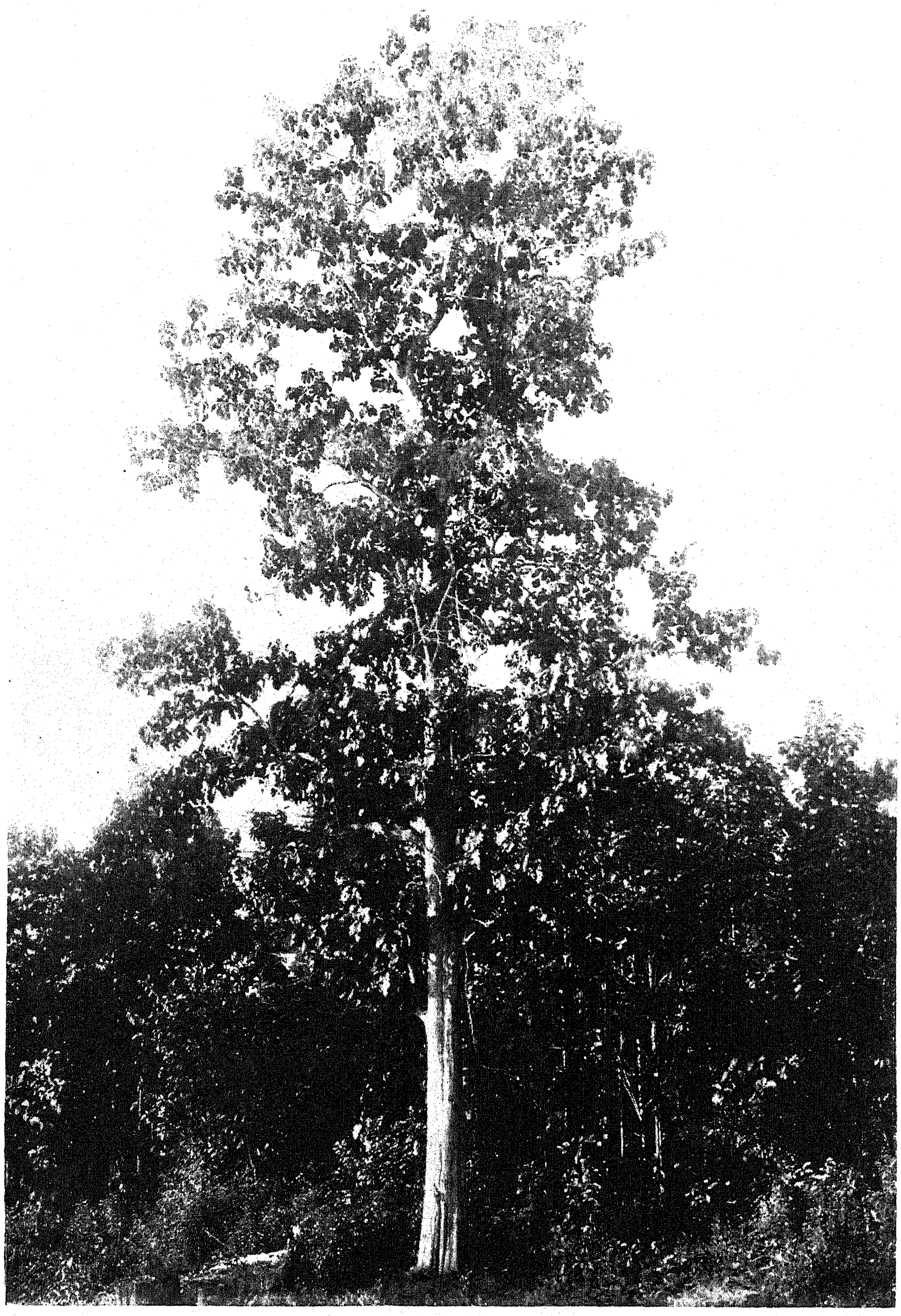

FIG. 262. *Tectona grandis*, girth 11 ft. 7 in., Minyé, Toungoo, Burma.

FIG. 263. Teak tree, height 152 ft., girth 10 ft. 3 in., bole 93 ft., estimated to contain 282 cubic ft. of timber, Mohnyin reserve, Katha, Upper Burma. Note man at base.

FIG. 264. Pure teak forest, Mohnyin, Katha, Upper Burma. Tree in centre with man at base, 11 ft. 4 in. in girth, 135 ft. in height, 93 ft. bole, estimated to contain 320 cubic ft. of timber.

Calthrop measured a tree 20 ft. in girth at 6 ft. from the ground, with a clear bole of 60 ft. to the first branch. Two trees measured by me in 1906 in the Mohnyin forest, Katha, had the following dimensions :

(1) Girth at breast-height 10 ft. 3 in., height 152 ft., bole 93 ft., estimated to contain 282 cub. ft. of timber.

(2) Girth at breast-height 11 ft. 4 in., height 135 ft., bole 93 ft., estimated to contain 320 cub. ft. of timber.

These two trees are shown in Figs. 263 and 264.

Mr. C. G. Rogers [1] records the cubic contents of five trees recently felled and logged in the Mehaw reserve, Pyinmana, as follows :

	No. of logs yielded.	Total length of logs.	Mean girth of bottom log.		Total volume.
		ft.	ft.	in.	cub. ft.
(1)	6	153	13	6	862
(2)	3	78	13	6	663
(3)	3	81	13	6	737
(4)	3	86	11	3	531
(5)	4	72	18	0	687

These trees grew on rich well-drained soil at the foot of the hills east of the Sittang river. Mr. Rogers also records in the Gamôn reserve of the Zigôn forest division, a tree with a height of 153 ft. and a breast-height girth of 15 ft. 10 in.

Among large logs recorded from Burma is one mentioned by Dr. J. Nisbet.[2] It was cut in the Shweli forests, Ruby Mines district, by Messrs. Darwood & Co., and launched in one of the floating streams about 1898; it was quite sound, had a length of 82½ ft., a butt girth between 12 and 13 ft., a top girth between 7 and 8 ft., and a mean girth of 10 ft., and contained 516 cub. ft. of timber. Another sound log recorded by Mr. S. Carr [3] in the Yamethin district had a length of 64 ft. and a mean girth of 13 ft. 9 in., giving a volume of 756 cub. ft.

General distribution. Teak is indigenous throughout the greater part of Burma and the Indian Peninsula, in Siam, and in Java and other islands of the Indian Archipelago. In Burma the northern limit of teak lies about 25° 30′ N. lat., that is, some distance outside the tropics, while its southern limit is in the Amherst district between 15° and 16° N. lat.; on the east it extends beyond the frontiers of the province, while on the west it does not extend beyond the western watershed of the Irrawaddy and Chindwin rivers. In the Indian Peninsula the northern limit of teak is in the western Aravallis in Rajputana at 24° 42′ N. lat., thence eastward through Central India to the Jhansi district at 25° 33′, entering the Banda district, thence in a south-easterly direction to the Mahanadi river. From this northern limit it extends southward to Tinnevelly and Travancore. In Burma and the Indian Peninsula it is by no means continuous within the limits mentioned, but is confined to tracts of greater or less extent separated by other tracts where it is absent or of very local occurrence.

Although the teak reaches large dimensions in some of the forests of western and southern India, Burma is the great source of supply of large-

[1] Ind. Forester, xliv (1918), p. 417.
[2] *Ibid.*, xxiv (1898), p. 320.
[3] *Ibid.*, xxii (1896), p. 465.

sized timber for the European market, and the vast teak forests of that province constitute one of its greatest natural assets. Nevertheless even the poorer classes of teak forest in the Indian Peninsula are of considerable value as sources of local supply in the shape of poles and timber for building and other purposes.

Teak has been planted in many localities outside its natural region. Plantations on a small scale have been formed in the United Provinces, Bengal (including Chittagong), Assam, Bihar and Orissa, Arakan, and the Andamans ; a short account of some of these plantations is given below (pp. 733–4). The tree is frequently planted in parks and gardens as far north as Saharanpur, Dehra Dun, and even Lahore, as well as in other places outside its natural region.

CLIMATE. Although teak occurs in dry localities, subject to great heat and drought in the hot season, it thrives best and reaches its largest dimensions in a fairly moist, warm, tropical climate, though in very moist tropical regions it tends to be replaced by evergreen forest. It extends into regions of slight frost, but throughout almost the whole of its distribution frost is unknown. It occurs where the normal rainfall is 30 in. or even less, as in Khandesh, Ahmednagar, Nimar, Buldana, and West Kurnool, and is also found where the rainfall is as much as 150–200 in., as on the west coast of India and in Tenasserim. Actually it appears to thrive best with a normal rainfall varying from 50 to 150 in. The most important teak areas of Burma are situated in regions where the normal rainfall varies from 50 to 120 in. In the Indian Peninsula it experiences in places absolute maximum shade temperatures up to about 118° F., and absolute minimum shade temperatures down to about 36° F., but these extremes denote a drier climate than is favourable to its development. In the moist parts of the west coast, where it reaches larger dimensions than in the drier parts of its Indian peninsular region, the climate is much more equable, the absolute maximum shade temperature varying from 95° to 100° F., and the absolute minimum from 55° to 62° F. In the more important teak areas of Burma the absolute maximum shade temperature varies from 102° to 110° F., and the absolute minimum from 39° to 55° F.

TOPOGRAPHY, GEOLOGY, AND SOIL. The majority of the teak forests are situated on hilly or undulating country, but there are considerable areas on flat alluvial ground provided it is well drained, not only on plains of some extent, but also on alluvial flats of limited size along the banks of rivers and streams. On well-drained deep alluvial soil teak sometimes occurs remarkably pure, and attains large dimensions. It also attains very good development on the fertile lower slopes of hills where the soil is deep, but along dry ridges it becomes stunted, as is also the case on shallow soil. Above all, the teak requires good subsoil drainage, and will not endure stiff soil which is liable to inundation or to water-logging. In the plains forests of Burma teak is sometimes confined to the fringes of well-drained ground along the banks of watercourses, avoiding the ground away from the streams where the drainage is not so good. In the Nilambur teak plantations of South Malabar, in which the stock has been carefully classified according to quality, it is found that drainage exercises a great influence on the quality. Here flat alluvial ground does not produce first quality crops unless it is close to the main river, the growth deteriorating

to second quality at a short distance from it, even where the ground is well drained by feeders; where the drainage is at all deficient third quality is the result.

Teak is found on various geological formations, but the extent to which it flourishes depends largely on the depth, drainage, moisture, and fertility of the resulting soil. It grows well in Burma on the soft tertiary sandstones and shales of the Pegu Yoma and parts of the Chindwin drainage, where the resulting soil varies from sandy to clayey loam, usually of good depth and drainage. It is fairly plentiful in the sandstone areas of the Indian Peninsula, particularly on the Vindhyan sandstones, but on hard metamorphosed sandstone or quartzite, which disintegrates with difficulty, the teak becomes stunted and of poor growth. Teak flourishes on granite, gneiss, schists, and other metamorphic rocks in the hills east of the Sittang river, in the Ruby Mines district, and parts of the Madaya drainage of Burma, as well as in North Kanara, Malabar, the Anamalai hills, Coorg, and elsewhere in the Indian Peninsula. The soil resulting from granite and gneiss is often very sandy or gravelly and porous, and on ridges and in dry situations generally it may become unfavourable for the growth of teak. On the limestone of the Thaungyin valley, the Ruby Mines district, the Madaya valley and parts of the Chindwin drainage of Burma, teak flourishes well where the rock has disintegrated to form a deep loam, though on hard limestone with a shallow soil the growth is poor. Teak occurs on limestone in parts of the Central Provinces and locally in North Kanara. The great trap areas of the Indian Peninsula are extensively covered with teak. As a general rule the soil is of no great depth, and although teak is often remarkably plentiful, it is of small size; only in valleys and on lower slopes, where there is some depth of soil, does the tree attain fair dimensions in the trap areas. Teak as a rule avoids laterite, and where found on this rock it is invariably stunted; only where the laterite is highly disintegrated and mixed with other rocks does it attain any size.

LOCAL OCCURRENCE AND TYPES OF FOREST. *Burma.* The general limits of teak in Burma have already been given. The tree does not extend to (1) Arakan, South Tenasserim, and the extreme north of Upper Burma, where, apart from other possible reasons for its absence, the heavy rainfall frequently renders the forest evergreen in type; (2) low-lying savannah lands, tidal regions of the delta, many laterite areas, and other places which are unsuitable for its growth; (3) elevations higher than about 3,100 ft.; (4) the drier parts of the dry zone of Upper Burma. It occurs round the fringes of the dry zone, but does not extend into regions where the rainfall is much below 40 in.; outlying patches of teak within the dry zone occur on the lower slopes and round the base of Popa mountain in the Myingyan district, but here the rainfall is heavier than in the drier tracts around, and the soil is composed of fertile volcanic débris. Elsewhere teak occurs in suitable localities throughout the greater part of the province, though there are considerable tracts where it is absent.

In 1917 the total area of teak-bearing forest in Burma was roughly estimated to be 35,000 square miles. The majority of these forests are situated on hilly or undulating ground, but there are some important forests situated on flat ground of alluvial origin. Perhaps the most important stretch of teak-

bearing forest in the province is on the Pegu Yoma, a range of hills composed of tertiary sandstone and shale and forming for the greater part of its extent the watershed between the Irrawaddy and Sittang rivers: these forests form an unbroken stretch more than 200 miles in length and averaging about 30 miles in breadth. There are also extensive teak tracts in the drainages of the Salween, particularly in the Southern Shan States, of the Thaungyin, the Chindwin and its tributaries, and the upper Irrawaddy, including the Shweli, Madaya, and other important drainages. Teak forests of varying extent occur also on the eastern slopes of the Arakan Yoma, in the hills east of the Sittang river, and in the Ataran drainage. The Myitngè river drainage contains several teak areas, partly in the Northern Shan States and partly in the Yeyaman tract of the Kyauksè district.

Teak occurs normally in mixed deciduous forests, but occasionally teak trees are found standing in dense evergreen forest (see Fig. 265). These trees are often of very large size, testifying to the fertility of the soil. Such cases are examples of progressive succession from a deciduous to an evergreen type, for the teak is incapable of regenerating in dense evergreen forest, and must have established itself when the forest was of a deciduous type. The gradual encroachment of evergreen species in moist deciduous forest can often be observed, particularly in areas where fire-protection has been introduced, and in some cases teak trees may be found recently killed by the suppression of faster-growing invasive species.

The teak-bearing forests of Burma may be classified into numerous sub-types, but the more important of these can be referred to one of two main types which Kurz designated 'upper mixed' and 'lower mixed' respectively, terms which have been adopted generally and are well understood. The general distinction between these two main types is as follows: (1) upper mixed forest (Fig. 266) as a rule occupies hilly or undulating country, and is usually characterized by the prevalence of bamboos; (2) lower mixed forest (Fig. 267) occurs on lower ground, which is flat or nearly so, and is usually alluvial, white bamboos are either absent or not well distributed. Both these types are essentially deciduous, but in their moister parts they tend to merge into evergreen, while the two types may merge imperceptibly into each other, so that a sharp line cannot always be drawn between them. The upper mixed forests are by far the more extensive, and may be regarded as the true home of the teak; some of the richest teak areas, however, are to be found in lower mixed forest.

The upper mixed forests may be divided into two chief sub-types, (*a*) dry and (*b*) moist, according to the comparative dryness or moistness of the forest growth, of which the best indicators are the bamboos, which are such an important constituent of the crop. A sharp distinction cannot always be drawn between these two sub-types, more especially since the majority of the tree species associated with the teak occur in both.

In dry upper mixed forest the typical bamboo is *Dendrocalamus strictus*, but some of the bamboos of the moist forest, notably *Cephalostachyum pergracile*, often in stunted form, extend into dry forest. *Bambusa Tulda* occurs in both, and *Thyrsostachys Oliveri* is found in somewhat dry types as well as in fairly moist types in Upper Burma. Dry upper mixed forest may either

FIG. 265. Teak in evergreen forest, Mogaung, Upper Burma.

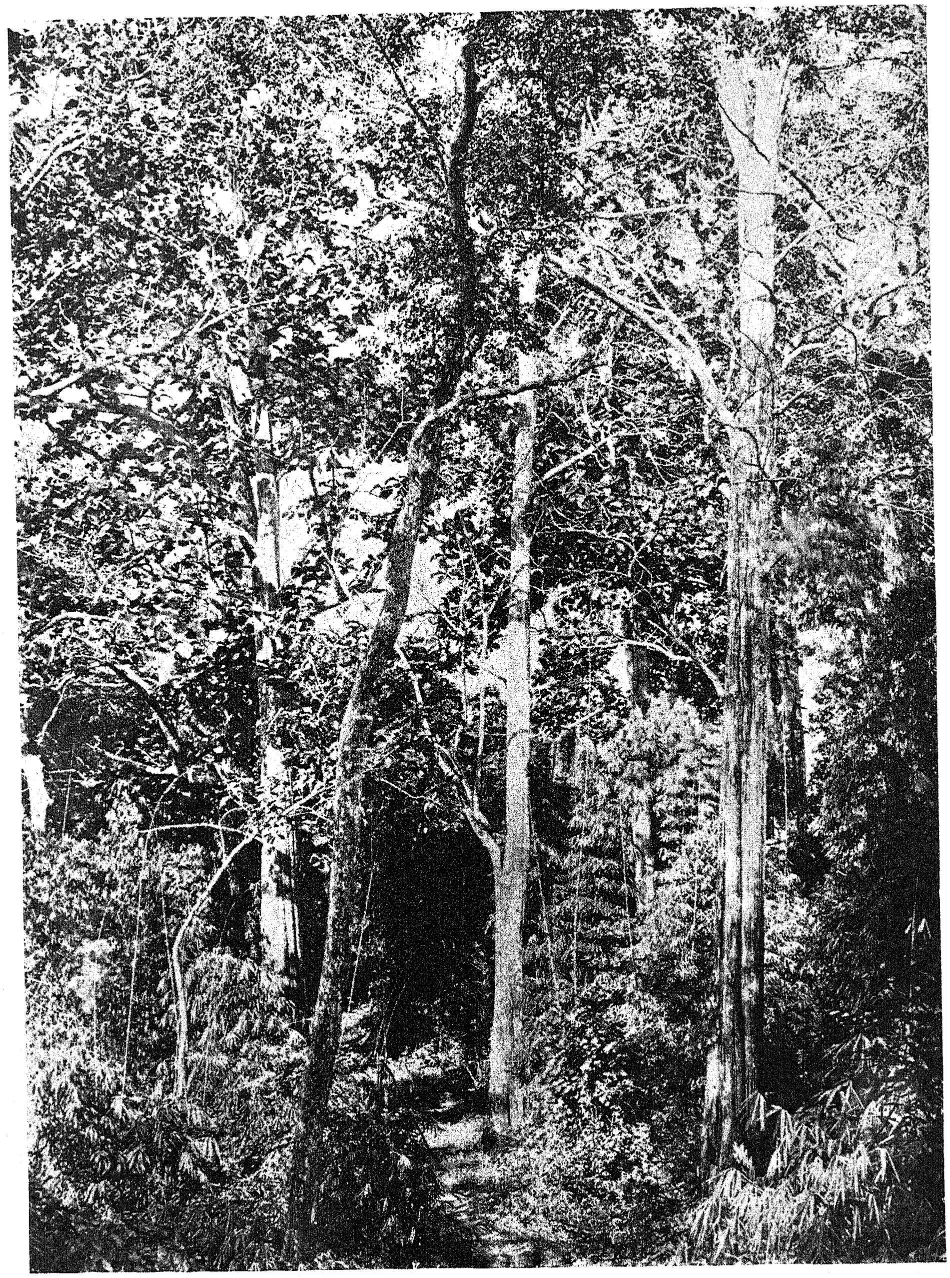

FIG. 266. Teak in upper mixed forest, Bhamo district, Upper Burma: the bamboo is young *Cephalostachyum pergracile*.

occur in unbroken stretches of considerable extent or be confined to the crests and upper slopes of ridges and spurs, the lower slopes of which are occupied by moist forest. As a rule teak does not attain such large dimensions in dry as in moist forest, but it reproduces itself more freely in the former. The most typical associates of teak in dry forest are *Xylia dolabriformis*, *Terminalia tomentosa*, *T. Chebula*, *Acacia Catechu*, *Pterocarpus macrocarpus*, *Homalium tomentosum*, *Shorea obtusa*, *Pentacme suavis*, *Dalbergia cultrata*, *Bombax insigne*, *Sterculia* spp., *Premna tomentosa*, as well as many other species.

A particular form of somewhat dry forest is that known by the Burmans as *thitkyin*, in which bamboos are scarce or absent and there is often an undergrowth of thorny twiners ; the most characteristic trees are teak, *Xylia dolabriformis*, *Terminalia tomentosa*, *Homalium tomentosum*, and *Lagerstroemia Flos-Reginae*, and there is sometimes a dense advance growth of young *Xylia*.

In moist upper mixed forest the prevailing bamboos vary with locality. Throughout the Pegu Yoma and in certain other tracts the most typical species are *Bambusa polymorpha* and *Cephalostachyum pergracile* in its more luxuriant form ; the latter has a wide range in Burma. Locally common is *Oxytenanthera albociliata*, often on sandy soil. In moist valleys of the Pegu Yoma, *Dendrocalamus longispathus* is common, and where the moist forest merges into evergreen forest dense masses of *Teinostachyum Helferi* cover the ground. In the northern parts of Upper Burma among the commoner bamboos of the moist mixed forest are *Dendrocalamus Brandisii*, *D. Hamiltonii*, and *D. membranaceus*, with *Cephalostachyum pergracile* plentiful in some localities.

The commoner tree species associated with teak in the moist upper mixed forests are *Xylia dolabriformis*, *Lagerstroemia Flos-Reginae*, *L. tomentosa*, *Anogeissus acuminata*, *Terminalia belerica*, *T. pyrifolia*, *Homalium tomentosum*, *Adina cordifolia*, *A. sessilifolia*, *Stephegyne diversifolia*, *Vitex glabrata*, *Bombax insigne*, *Eugenia* spp., and where the forest merges into evergreen, *Dipterocarpus alatus*.

In the lower mixed deciduous forests teak is associated with *Xylia dolabriformis*, *Lagerstroemia Flos-Reginae*, *L. tomentosa*, *Dipterocarpus alatus*, *Berrya Ammonilla*, *Terminalia tomentosa*, *T. pyrifolia*, *T. belerica*, *T. Chebula*, *Adina cordifolia*, *A. sessilifolia*, *Stephegyne diversifolia*, *Odina Wodier*, *Spondias mangifera*, *Eugenia Jambolana*, *Eriolaena Candollei*, *Careya arborea*, *Vitex glabrata*, *Dillenia pentagyna*, *Miliusa velutina*, *Diospyros ehretioides*, *Dalbergia cultrata*, *D. purpurea*, *Kydia calycina*, *Pterospermum semisagittatum*, *Phyllanthus Emblica*, *Anogeissus acuminata*, *Bridelia retusa*, *Schleichera trijuga*, and many others. In these forests teak avoids the badly drained areas, but where the drainage is good it may become very plentiful and may reach large dimensions.

Particularly rich teak forests of the lower mixed type are the Kangyi and Satpôk reserves in the Tharrawaddy district, both of which are outlying forests on the alluvial plain of the Myitmaka river. To this type may be referred the interesting forest of Mohnyin in the Katha district of Upper Burma (see Fig. 264). This forest is situated on flat or nearly flat ground on deep alluvial soil. Over part of the area teak forms the bulk of the growing stock, and in places is practically pure, and the trees reach very large dimensions. The peculiarity about this forest, apart from the high percentage of

teak it contains, is that the trees are mainly of large dimensions, the proportion of small trees being very deficient ; natural reproduction is almost entirely wanting until special measures, which are described later, are taken to stimulate it. Bamboos are absent over much of the area ; the chief companions of the teak are *Gmelina arborea*, *Anogeissus acuminata*, and *Careya arborea*. Although the teak trees attain large size the timber is not of the best quality, being much riddled by the bee-hole borer (*Duomitus ceramicus*, Wlk.).

In some localities, notably in the Ruby Mines district, teak occurs in belts or pockets which follow the courses of streams, large stretches of intervening country being covered with *indaing* or other types of forest devoid of teak. The teak confines itself to the alluvial flats or other fertile ground in the neighbourhood of the watercourses. Throughout Burma, in forest both of the upper and of the lower mixed types, teak is very commonly found, sometimes in gregarious form, on well-drained alluvial flats of varying size, on the fertile loam of which it may attain large dimensions. Bamboos are often absent in such places, or if they are present the commonest species is *Bambusa Tulda*. Teak is sometimes found in *indaing* forest on laterite, but in this type it is invariably stunted.

As a general rule teak forms a comparatively small proportion of the growing stock in the forests of Burma, the trees being scattered singly or in groups among a large number of other species. Some years ago I made an examination of the numerous statistics contained in the various working plans which have been compiled for the teak forests, and published the results.[1] The figures yielded—including those furnished by the Mosit reserve in Bhamo, the working plan of which has been issued since—show that over the teak-bearing area of whole forests, that is, whole working circles and not selected areas rich in teak, the average number of teak trees 6 ft. or over in girth per 100 acres is 100 or more in respect of fourteen forests hitherto enumerated, aggregating 972 square miles of teak-bearing forest ; of these the Mohnyin forest heads the list with 241 such trees per 100 acres. Only four of these forests have 100 or more teak trees 7 ft. in girth and over per 100 acres.

Considering next those forests which are rich in sound teak trees 3 ft. and over in girth, it is interesting to note that the three richest forests are situated on flat alluvial ground. The three forests in question are :

1. Mohnyin (Katha division), 707 trees per 100 acres.
2. Satpôk (Tharrawaddy division), 455 trees per 100 acres.
3. Kangyi (Zigôn division), 441 trees per 100 acres.

Satpôk and Kangyi are typical lower mixed forests. Next in order of richness come two typical upper mixed forests of the Pegu Yoma, namely Bondaung (Toungoo) with 409 trees, and Kadinbilin (Tharrawaddy) with 408 trees. No fewer than nine forests have totals of between 300 and 400 sound teak trees 3 ft. and over in girth per 100 acres, and of these all but one are situated in the Pegu Yoma.

As regards the percentage of teak in the total growing stock in teak-bearing forest, in the twelve richest forests in which enumerations of all species have been carried out, the percentage of sound teak trees 3 ft. in girth and

[1] A Note on some Statistical and other Information regarding the Teak Forests of Burma. Ind. For. Records, vol. iii, pt. i, 1911.

over varies from 15 to 33, the two richest forests being situated in the Zigôn forest division; these are Bawbin with 33 per cent., and Kangyi with 29 per cent., the former being of the upper and the latter of the lower mixed type. These figures, however, do not include the Mohnyin forest, in which only teak was enumerated; this forest probably contains a much larger percentage of teak than any other. The lowest percentage of teak 3 ft. and over in girth in true teak forests hitherto enumerated is 6, in the Gwethe and Saing working circles of Toungoo.

Indian Peninsula, general distribution. The distribution and types of teak forest in the Indian Peninsula are determined mainly by rainfall and geological formation with resulting soil. The great majority of the teak areas are situated on one of two great systems of rocks: (1) the Deccan trap, which stretches from about 25° N. lat. southwards with occasional interruptions to about 16° N. lat., embracing parts of Central India and the Central Provinces, the greater part of Berar, the whole of the northern part of Bombay as far south as Belgaum, and the western part of Hyderabad; (2) the crystalline rocks (granite, gneiss, schist, &c.) which occur in Bundelkhand, in several parts of the Central Provinces, in the eastern part of Hyderabad, along the Western Ghats and throughout the greater part of the Madras Presidency. Broadly speaking, there is a marked difference in the types of teak forest found on these two geological formations. On the trap areas, where the soil is often very superficial, the teak is usually of small size but occurs in great abundance, often forming the bulk of the growing stock and even occurring pure over considerable areas. To some extent this is due to artificial causes, in that teak has been able to survive better than its companions the lopping, hacking, grazing, and burning to which many of the forest tracts have for long been subjected; in some cases also teak owes its prevalence to the fact that as a 'royal tree' it has received special protection in the past. On the crystalline areas, although the teak trees are as a rule more scattered than they are on trap, they reach considerably larger dimensions where the rainfall is favourable.

United Provinces. In the Jhansi district of the United Provinces teak occurs on gneiss and quartzite, and is confined to areas within a few miles of the larger rivers. It is found in the small forest of Sairwas, where it forms the greater part of the crop, in the protected forests of Talbehat, and occasionally on the bank of the Betwa river. The rainfall in these tracts is under 40 in., and the teak is of small size.

Central Provinces and Berar. In the Central Provinces and Berar teak occurs to a greater or less extent in Jubbulpore, Damoh, Saugor, Hoshangabad, Seoni, Chindwara, Nagpur, Wardha, Chanda, Balaghat, Bilaspur, Raipur, Buldana, Betul, and Amraoti (Melghat), and possibly to a small extent in other localities. In Bilaspur, Balaghat, and Raipur it is very local, occurring chiefly on alluvial ground near streams. Within its region the rainfall varies from under 40 in. to about 65 in., except in the Bori forest of the Hoshangabad district, where it is between 75 and 80 in. Teak occurs on a variety of geological formations, notably trap, limestone, gneiss, mica schist, sandstone, conglomerate, shale, and clay. It is usually absent from the quartzite plateaux, and although occasionally found on laterite, the growth is poor; it also avoids

black cotton soil. On trap areas teak is often very plentiful, though of small size. In some localities it attains a fair size on the Vindhyan limestone and sandstone or on alluvial ground near rivers. Teak is not ordinarily found with sal, but occasionally the two occur mixed, for example in the Bilaspur district, where there is a small area of teak mixed with sal poles near Deosara in the West Lormi range. The requirements of the two species differ, teak seeking good subsoil drainage combined with a fair rainfall, and sal seeking the more hygroscopic soils.

Teak is one of the constituents of the mixed deciduous forests which are so typical of the Central Provinces. Its chief companions are *Terminalia tomentosa*, *T. belerica*, *Lagerstroemia parviflora*, *Ougeinia dalbergioides*, *Anogeissus latifolia*, *Dalbergia latifolia*, *D. paniculata*, *Pterocarpus Marsupium*, *Diospyros Melanoxylon*, *Acacia Catechu*, *Chloroxylon Swietenia*, *Soymida febrifuga*, *Schleichera trijuga*, *Schrebera swietenioides*, *Gmelina arborea*, *Cleistanthus collinus*, *Odina Wodier*, *Cassia Fistula*, *Bridelia retusa*, *Adina cordifolia*, *Stephegyne parvifolia*, *Butea frondosa*, *Bassia latifolia*, *Phyllanthus Emblica*, *Buchanania latifolia*, *Xylia xylocarpa* (in Chanda), and *Boswellia serrata* (in dry places and on ridges). The prevailing bamboo in teak-bearing forest is *Dendrocalamus strictus*, but occasionally *Bambusa arundinacea* is found on alluvial flats by rivers. The type and quality of the forest, and the actual companions found with the teak, vary according to local conditions. In the great majority of cases the teak is of comparatively small size, and it has often suffered from past maltreatment in the shape of lopping, grazing, and burning, in consequence of which many trees are unsound or misshapen.

The largest teak in the Central Provinces is produced in South Chanda, in which the most important forests are those of Allapilli in the Ahiri range, forming a compact block about 73 square miles in area and situated about 70 miles south of Chanda. The north-west and central parts of this tract are flat or undulating, the remainder being hilly, the Bhimaram hills in the south-west rising to 1,600 ft. above sea-level. The rock is metamorphic, chiefly granitic ; the soil is a rich light loam, but is shallow and rocky on the hill ridges. The rainfall is about 50 in. The forests of the Bhimaram hills are characterized by a plentiful growth of bamboo (*Dendrocalamus strictus*). Teak is the most plentiful tree species, the forest consisting in many places of large teak trees standing between bamboo clumps, with scattered individuals of *Dalbergia latifolia*, *Pterocarpus Marsupium*, and *Stephegyne parvifolia*, while *Schleichera trijuga* is common in the valleys. At the base of the hills and in the valleys the forest is more varied, the teak being associated with *Terminalia tomentosa*, *Stephegyne parvifolia*, *Adina cordifolia*, *Diospyros Melanoxylon*, *Anogeissus latifolia*, *Odina Wodier*, *Xylia xylocarpa*, *Holarrhena antidysenterica*, *Butea frondosa*, *Cleistanthus collinus*, and others. These species extend to the Bhimaram plains forests, where teak greatly predominates, and to the Mirkullu block, though the hilly portions of the latter are occupied by a very dense growth of bamboo, the result of former shifting cultivation.

Another interesting teak forest in the Central Provinces is the Bori forest in the Hoshangabad district. This forest is situated in a deep valley at an average elevation of 1,450 ft. above sea-level, through which runs the Bori river ; this valley is enclosed on the north by a scarped ridge rising to 3,777 ft.,

and on the south by several minor ridges rising to 1,900 ft. above sea-level. The rocks are partly trap, partly massive sandstones of the upper Gondwanas, and partly soft sandstones, clays, and shales of the lower Gondwanas. The soils resulting from these rocks are often intermingled, the result being favourable to forest growth, though the teak is most abundant and of best growth where trap predominates. An important factor is the rainfall, which is between 75 and 80 in., and is considerably higher than in any of the neighbouring parts of the Peninsula. Teak is the predominant tree, especially on alluvial ground along river-banks, where it may form as much as 90 per cent. of the crop. The chief associate species are *Ougeinia dalbergioides*, *Terminalia tomentosa*, *Diospyros Melanoxylon*, *Lagerstroemia parviflora*, *Anogeissus latifolia*, *Pterocarpus Marsupium*, *Dalbergia latifolia*, and many of the other common trees of the Central Provinces. Bamboos (*Dendrocalamus strictus*) are also plentiful. Teak is capable of reaching very fair dimensions, and coppice-shoots show remarkable growth, attaining a height of 100 ft. and a girth of 6 ft.

Bombay. The most important teak forests of the Bombay Presidency are those of North Kanara, where under the influence of a heavy rainfall and favourable soil the trees attain large dimensions. The rocks are chiefly crystalline (granite, gneiss, schist, limestone, quartzite, &c.), with occasional trap or sandstone and shale, and the soil is often a deep rich loam. Laterite is frequent, but the teak avoids pure laterite soils. The best teak areas of the Western Ghats and below-*ghat* tracts of North Kanara are in the regions of heavy rainfall, that is, where the rainfall is over 60 in., and may reach 150 in. or more. Here the teak reaches large dimensions on well-drained slopes such as those of the Kalinaddi and Gangawuli river drainages.

Teak occurs only in mixed deciduous forests, and although occasional trees are found standing in evergreen forest this, as in Burma, indicates recent encroachment of evergreen species in former forest of a deciduous type. In the Kanara high forests, teak is a scattered tree, forming a comparatively small proportion of the growing stock. Farther inland, where the rainfall is less, the teak diminishes in size but increases in relative quantity; thus the eastern parts of Kanara, and the adjoining forest tracts of Belgaum and Dharwar, where the rainfall varies from 35 to 60 in., are the regions of teak pole forests. The chief companions of the teak in the forests of Kanara are *Terminalia tomentosa*, *T. paniculata*, *T. belerica*, *Lagerstroemia lanceolata*, *L. parviflora*, *Dalbergia latifolia*, *Pterocarpus Marsupium*, *Xylia xylocarpa*, *Adina cordifolia*, *Stephegyne parvifolia*, *Grewia tiliaefolia*, *Schleichera trijuga*, *Stereospermum xylocarpum*, *Anogeissus latifolia*, *Saccopetalum tomentosum*, *Dillenia pentagyna*, and *Careya arborea*. The bamboos are *Bambusa arundinacea* on the lower slopes and in the valleys, *Dendrocalamus strictus*, and *Oxytenanthera monostigma*, the last-named often forming on the upper slopes a dense undergrowth which hinders natural reproduction.

Outside North Kanara, Belgaum, and Dharwar, teak is found over a considerable portion of the great trap area extending from Surat and Khandesh in the north to the northern parts of Kanara and Belgaum in the south, as well as on the gneiss, schist, sandstone, and quartzite of the Panch Mahals. In the Khandesh Akrani teak ascends to 3,700 ft. Throughout the great bulk of the trap area the teak is of comparatively small size, but, as elsewhere on

trap formation, it forms as a rule a large percentage of the growing stock, sometimes occurring practically pure over considerable areas. The rainfall over most of the trap areas of Bombay varies from under 30 in. to about 70 in., but in the *ghat* regions of Thana and Nasik it is in places over 100 in. Where the rainfall is small the growth is extremely poor, and reproduction is largely from shoots sent up from stools and old thickened root-stocks; here the teak suffers periodically from drought. Even where the rainfall is heavy the soil is often shallow and rocky and the trees do not reach large dimensions, though occasionally in valleys and ravines where there is some depth of soil, fair growth is attained. In the Dangs of Surat and the Khandesh Akrani teak attains a larger size than in most parts of the trap area, but the larger trees are usually unsound owing to past maltreatment.

The companions of the teak in these forests are much the same as those occurring in most of the Central Provinces teak forests, and include *Terminalia tomentosa*, *T. belerica*, *T. Chebula*, *Lagerstroemia parviflora*, *Adina cordifolia*, *Stephegyne parvifolia*, *Grewia tiliaefolia*, *Pterocarpus Marsupium*, *Dalbergia latifolia*, *Ougeinia dalbergioides*, *Phyllanthus Emblica*, *Cassia Fistula*, *Acacia Catechu*, *Diospyros Melanoxylon*, *Butea frondosa*, *Bridelia retusa*, *Odina Wodier*, *Soymida febrifuga*, *Erythrina suberosa*, *Schleichera trijuga* (chiefly near water-courses), and *Boswellia serrata* (in dry places). The bamboos, where present, are *Dendrocalamus strictus* and, on the more fertile ground or where the rainfall is heavy, *Bambusa arundinacea*.

Southern India. The most important natural teak areas of southern India are in North and South Malabar, particularly in the Wynaad, the Anamalai hills, Coorg, the south-western part of Mysore, and Travancore, that is, in the south-westerly part of the Peninsula. The rocks are for the most part metamorphic (granite, gneiss, and schist), and the rainfall in the best teak areas is chiefly between 60 and 150 in., but is more in places. Teak here occurs in mixed deciduous forest; the companion species are much the same as those of North Kanara, and include *Terminalia tomentosa*, *T. belerica*, *T. paniculata*, *Dalbergia latifolia*, *Lagerstroemia lanceolata*, *Pterocarpus Marsupium*, *Grewia tiliaefolia*, *Schleichera trijuga*, *Anogeissus latifolia*, *Adina cordifolia*, *Stephegyne parvifolia*, *Stereospermum xylocarpum*, *Careya arborea*, *Bombax malabaricum*, and *Gmelina arborea*. *Xylia xylocarpa* occurs below the *ghats*, sometimes associated with teak. The chief bamboo is *Bambusa arundinacea*, with *Dendrocalamus strictus* on drier slopes.

In Malabar teak flourishes and reaches large dimensions, both in the Wynaad, at elevations of over 2,000 ft., with a rainfall of about 80 to 140 in. and at lower elevations below the *ghats*, where the rainfall is heavier. The Nilambur valley of South Malabar is celebrated for its extensive and remarkably successful teak plantations, commenced in 1844 and continued to the present day. In the Anamalais teak grows to a large size on fertile loam resulting from the decomposition of gneiss. The teak forests are of a somewhat moist type, the chief associate species being those just mentioned, and there is often a dense herbaceous undergrowth which prevents teak reproduction.

The forests of Coorg fall into two main tracts—the eastern forests, at an altitude of 2,600 to 4,488 ft., with a rainfall varying from 124 in. at Mercara

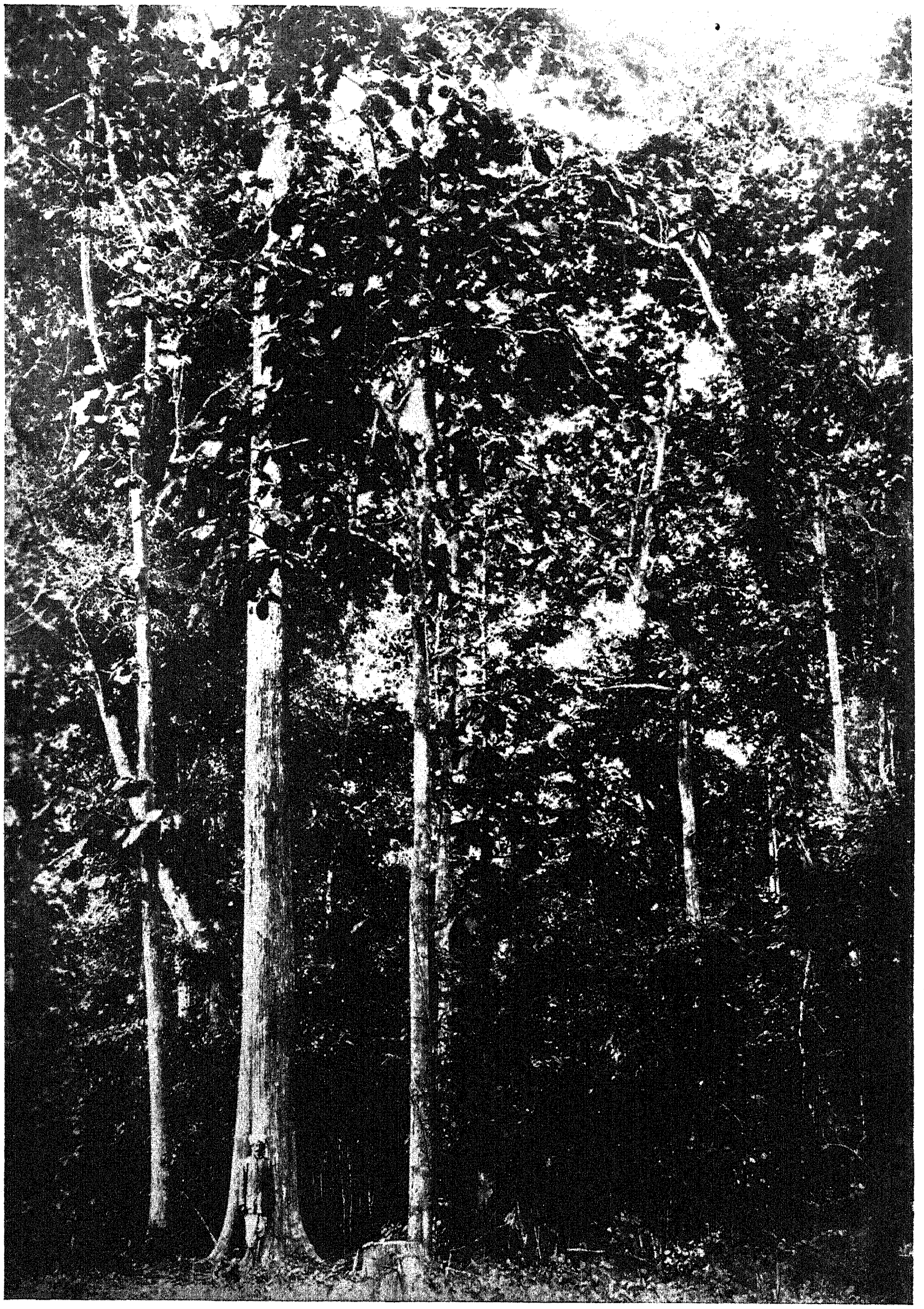

Fig. 267. Teak in lower mixed forest, Pyinmana, Upper Burma: on right of large teak tree is a *Dillenia* tree.

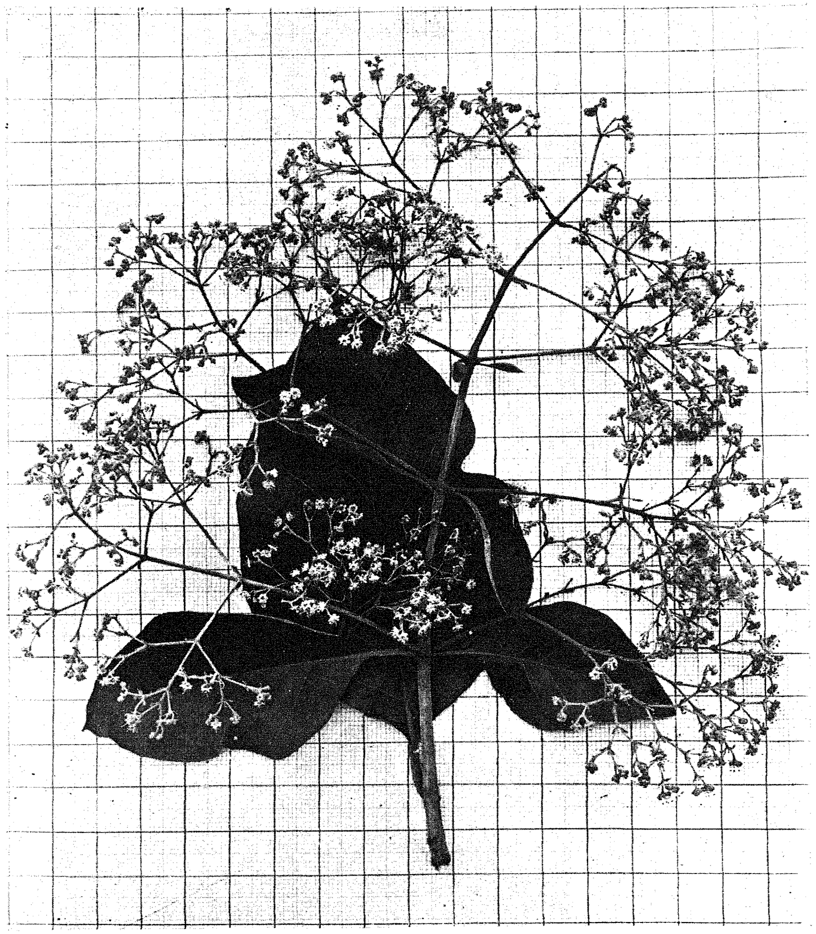

FIG. 268. *Tectona grandis,* inflorescence. Squares show inches and tenths.

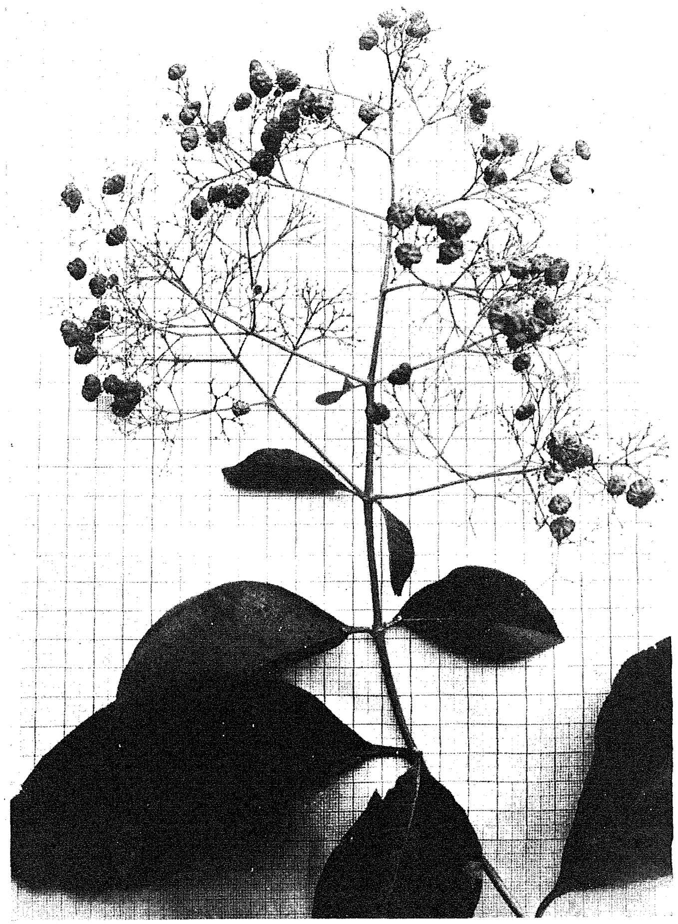

FIG. 269. *Tectona grandis,* fruiting panicle. Squares show inches and tenths.

to 42 in. at Fraserpet, and the *ghat* forests, situated on the slopes of the Western Ghats and in the tracts below, where the rainfall is probably as much as 300 in. or more in places. The rock is chiefly gneiss, which is covered as a rule with a considerable depth of soil; laterite is found in places, but the teak avoids pure laterite. The eastern forests may be roughly divided into two zones, the dry eastern or teak zone and the western or moist zone. In the former teak is plentiful, but in the drier parts to the east the forest is open and the growth is poorer than it is farther west; in the south-eastern forests the growth is better. The western zone is characterized by a luxuriant growth of *Bambusa arundinacea*; the forest is well stocked with numerous tree species of good growth, but teak is comparatively rare, though existing plantations indicate that the locality is well suited to its growth. The *ghat* forests are mainly evergreen, and are not teak-bearing.

In Travancore teak grows at various elevations up to 3,000 ft., though at the higher levels it does not thrive. It is found on sandstone, granite, and limestone, as well as on alluvial ground along rivers. The best teak is found on the lower slopes of hills up to 2,000 ft. elevation; the Idiyera valley was at one time celebrated for the size and quantity of its teak, but extensive working, dating from 100 years ago or more, has depleted this and other favourable localities. In Travancore, as elsewhere, teak grows in mixed deciduous forests, its chief companions being those noted above for south-west India in general. The common bamboo is *Bambusa arundinacea*, while in the Idiyera valley the teak is found growing among thickets of the reed-like bamboo, *Ochlandra travancorica*, Benth. In Travancore the teak grows best where the rainfall is 100 in. or more. In the drier parts of the state, particularly in the extreme south, it is of small size, but grows in fair quantity, often forming the greater part of the growing stock.

Among other teak localities in the Madras Presidency may be mentioned Coimbatore (apart from the Anamalai hills) chiefly on gneiss, Tinnevelly on granite and schist, South Cuddapah up to 3,900 ft., the Yerramalais of West Kurnool, where the rainfall is only about 25 in., and teak occurs locally in stunted form, chiefly on shale, and along the Godavari river. The Godavari forests are situated partly on hilly and partly on level ground; the soil is fertile and is capable of producing fair-sized timber, but the forests have suffered from past over-felling and from shifting cultivation. The teak wood from these forests is figured and ornamental, and is prized for furniture and cabinet-making. Among the chief associates of the teak in the Godavari forests are *Terminalia tomentosa*, *T. Chebula*, *Xylia xylocarpa*, *Dalbergia latifolia*, *Pterocarpus Marsupium*, *Lagerstroemia parviflora*, *Adina cordifolia*, *Anogeissus latifolia*, *Soymida febrifuga*, *Chloroxylon Swietenia*, *Diospyros Melanoxylon*, and *Cleistanthus collinus*.

LEAF-SHEDDING, FLOWERING, AND FRUITING. In dry situations and seasons the leaves fall from November to January, while in moist localities the tree may remain in leaf until March or even later. As a rule the trees are leafless throughout the greater part of the hot season. The new leaves ordinarily appear from April to June according to locality and season; in wet seasons they sprout early, while in abnormally dry seasons the trees remain leafless longer than usual

The large terminal panicles of small white flowers (Fig. 268) appear during the rainy season, as a rule from June to August or September according to season and locality, but in abnormally wet seasons they may begin to appear as early as April, as they did in Berar in 1915 as a result of frequent showers early in the year. During the rainy season the teak trees are conspicuous from a distance with their masses of white inflorescences. Mr. E. Marsden states that he observed the teak in full flower in the Tinnevelly district, Madras, in January 1917, and that this is apparently usual.

The fruits ripen from November to January and fall gradually, some remaining on the tree through part of the hot season. The fruit is a hard, bony, irregularly globose nut (Fig. 270, *a*), somewhat pointed at the apex, enclosed in a thick, felty, light brown covering, usually 0·4–0·6 in. in diameter, but varying much in size, containing one to three, rarely four, seeds. The nut is enclosed in the inflated bladder-like calyx, 0·8–1·5 in. in diameter. Throughout the cold season the feathery erect fruiting panicles (Fig. 269) are conspicuous on the trees. The fruit may be conveniently collected by clearing the ground under the trees in January and February and sweeping up the fruits every few days; the fruits may, if necessary, be lightly beaten off the trees with sticks. For convenience in storage and transport it is advisable to remove the bladder-like calyx. This can be done by half filling a bag with the fruits and vigorously rubbing and shaking it, after which the remains of the calyces can be separated from the nuts by winnowing. The nuts vary much in weight. In samples from Burma the number varied from 570 to 850 per lb., while in samples from the Central Provinces it varied from 900 to 1,400 per lb.

The teak seeds well almost every year, though occasional poor seed-years occur. The seed-crop may be partially destroyed by storms between the time of flowering and fruiting. Insects are sometimes responsible for the destruction of much of the seed-crop. Fertile seed begins to be produced at a comparatively early age. A plantation formed in 1873–4 at Ramgarh in the Gorakhpur district, United Provinces, commenced regenerating naturally when less than twenty years of age. Coppice-shoots flower and fruit abnormally early. Seed from coppice nine years old, collected in Saugor, Central Provinces, and tested by the Forest Botanist at Dehra Dun in 1908, germinated and produced healthy seedlings. This disposes of the idea that seed from coppice shoots is necessarily unfertile. Mr. G. M. Ryan,[1] however, states that germination tests with seed from coppice-shoots up to fifteen years old in Thana, Bombay, were unsuccessful. Old trees are capable of producing fertile seed: in Burma seed from large trees 10 ft. in girth and over has been tested on at least three different occasions and found to be quite fertile.

Individual tests reveal considerable differences in the percentage of fertility of teak seed, but as a rule the percentage is high in well-selected seed. The seed often fails to germinate the first year, particularly if sown late, and may lie dormant in the ground for one or more years before germinating. Seed stored for a year is usually found to germinate more freely than fresh seed. Various methods of hastening germination are described below under 'artificial reproduction'. The vitality of teak seed is remarkable. Two instances may be quoted in which seed has lain dormant for many years, retaining its fertility.

[1] Ind. Forester, xxx (1904), p. 456.

FIG. 270. *Tectona grandis*—SEEDLING × $\frac{5}{8}$

a—Nut b - g—Germination stages f - j—Development of seedling during first season

The first is the case of the Mohnyin forest in Katha, Upper Burma, situated on flat ground and consisting in parts of almost pure teak of large size but with no reproduction present. Some years ago experiments were undertaken to induce natural reproduction, among other measures tried being the clearing of undergrowth and the clean sweeping of the ground; this resulted in the appearance of dense masses of teak seedlings sprung from seed which had lain dormant in the ground, and which must have accumulated for years before producing seedlings in such quantities. In a portion of the Bilumyo forest near and of the same type as Mohnyin, all teak seed-bearers were girdled in 1911, and in 1915 the forest growth was cleared and burnt; this was followed by the plentiful appearance of teak seedlings from seed which must have lain dormant in the ground for at least four years.

The second instance is one recorded by Mr. A. W. Lushington [1] in the forests of the Nallamalais of Kurnool. Here from 1901 onwards clear-fellings made in a type of forest devoid of teak trees resulted in plentiful natural reproduction of teak: this is attributed to the fact that in the sixties of last century or later teak was abundant in these forests, whereas in the eighties or nineties a totally different type of forest arose by which the teak was temporarily ousted, and when from 1901 onwards this forest was cut, teak sprang up in abundance from seed which must have lain dormant in the ground for many years.

GERMINATION (Fig. 270, *b–g*). Epigeous. The nut splits open on one or two sides, or sometimes on three or even four sides, the side pieces separating from the central axis of the nut like valves. Through the openings thus caused the radicles first emerge and descend, the cotyledons soon making their way upwards through the cracks, leaving the testas within the nut. As the plant emerges the valves soon fall away from the central portion of the nut. One nut usually produces one or two seedlings, but occasionally as many as three or even four seedlings may be produced.

THE SEEDLING (Fig. 270).

Roots: primary root long, thick, terete, tapering, tomentose, whitish and delicate at first, becoming light brown and woody later: lateral roots numerous, moderately long, at first delicate, white, pubescent, afterwards fibrous. *Hypocotyl* distinct from root, 0·5–1 in. long, compressed, white turning green, tomentose and covered with minute dark red glandular dots. *Cotyledons*: petiole 0·1–0·25 in. long, channelled above, light green, tomentose, covered with minute dark red glandular dots: lamina 0·45–0·6 in. by 0·3–0·5 in., foliaceous, fleshy, broadly elliptical ovate, entire, apex emarginate, base cordate or truncate, convex and bright green above, concave and paler green beneath, minutely tomentose and covered on both surfaces with minute dark red glandular dots which turn black later, midrib depressed, basal lateral veins two, somewhat obscure. *Stem* erect, at first terete or slightly compressed, soon becoming quadrangular, green, tomentose, covered with glandular dots, at first dark red, soon turning black. *Leaves* simple, opposite decussate, exstipulate. Petiole 0·1–0·5 in. Lamina 1–12 in. or more by 0·4–10 in., elliptical ovate or obovate, acute or obtuse, base tapering, serrate or crenate, hispid above, coarsely pubescent beneath, both surfaces, particularly the lower, covered with glandular dots at first dark red, soon becoming black; venation prominently reticulate, the veins depressed on upper, raised on lower surface.

[1] Ind. Forester, xxxii (1907), p. 409.

Fig. 271 shows seedlings in various stages up to about two months old. During the first year the leaves remain comparatively small except in the case of vigorous seedlings which have grown under favourable conditions; these develop large leaves which may reach a length of over 1 ft. Fig. 272 shows a vigorous seedling during the first season. In the Nilambur plantations transplanted seedlings which are regularly weeded attain an average height of 6 ft. by the end of the first year on soils of good quality, the principal growth taking place not during the rainy season but as soon as it is over. Under less favourable conditions a height of not more than a few inches is attained during the first season. Healthy seedlings produce a stout taproot which may attain a length of 12 in. or more during the first season and 2–3 ft. or more by the end of the second season. Seedlings are leafless during part of the hot season.

Teak seedlings are decidedly sensitive to drought and to frost, particularly during the first year, when they are frequently killed outright. During the second and subsequent years frost does less permanent injury, and plants, if affected, have a better chance of recovery from the base. In the drier parts of the Peninsula drought is a common cause of death among seedlings, and it is of the greatest importance to secure early germination and vigorous development during the first rainy season, in order to enable the young plants to survive the subsequent dry weather. In dry localities the stems of seedlings are frequently killed back by drought for some years in succession, while the root-system develops until it attains sufficient vigour to produce a permanent stem. In the first year seedlings do not tolerate injury to the taproot, but in subsequent years it is possible to transplant them with a fair chance of success after pruning the root and stem. In nurseries seedlings are often killed through injury to the taproot by insects; the grub of the rhinoceros beetle (*Oryctes rhinoceros*) is one of the worst offenders.

Young teak plants have a wonderful power of recovery from damage by fire, and in burnt forests their stems may be killed back for many years in succession, while in the meantime they gradually produce a much thickened root-stock from which a permanent shoot is finally produced when conditions are favourable to its survival. It has been observed in Burma that seedlings lacking in vigour when thus killed back by fire subsequently produce much more vigorous shoots. Young teak plants are not readily browsed by cattle and other animals.

Teak seedlings are intolerant of shade, and thrive best entirely in the open; only in dry localities do they benefit in their earlier stages by side protection from the direct rays of the sun. They are very sensitive to any suppression by weeds, and it is a well-known fact that wherever weed-growth is to be feared the survival of teak seedlings cannot be ensured without regular weeding. This fact requires no demonstration to those who have had any experience of the cultivation of teak, but Fig. 273 may serve to demonstrate it to those who have not had such experience. This figure shows two parallel lines of teak sowings in the second year; line A, on the left, has been regularly weeded, with the result that the plants are healthy and vigorous, while line B, on the right, has been left unweeded, with the result that every seedling has been killed by weeds, although these are by no means heavy. These sowings were carried out at Dehra Dun in 1913.

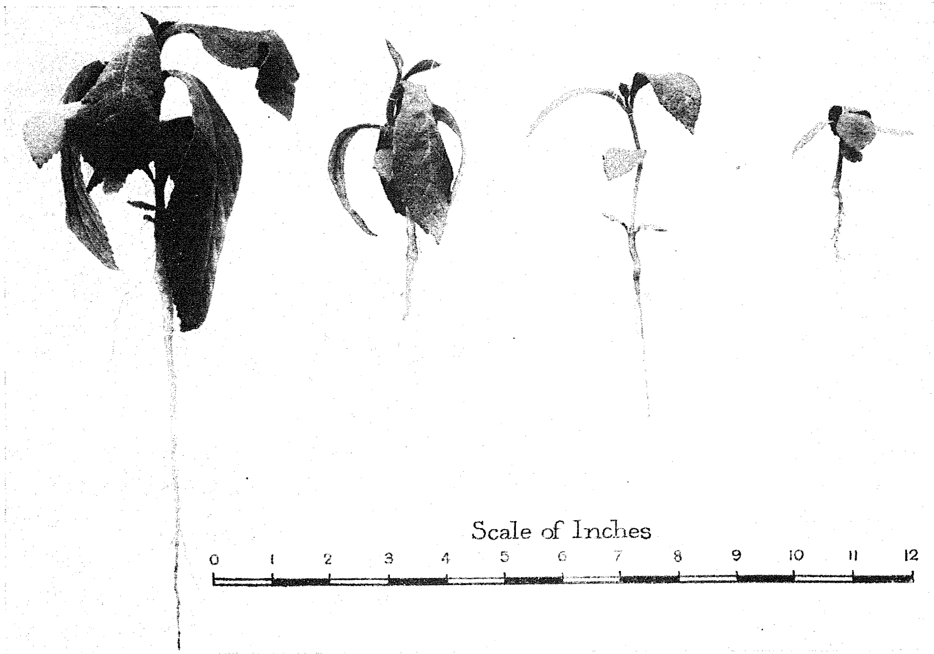

Fig. 271. *Tectona grandis,* seedlings in different stages up to 2 months old.

Fig. 272. *Tectona grandis,* vigorous seedling in first season. Staff shows feet

A B

Fig. 273. *Tectona grandis*, line sowings in second year, Dehra Dun, showing effect of weeding. Line on left (A) regularly weeded, line on right (B) sown at same time and left unweeded, resulting in complete failure.

The action of weeds in killing teak seedlings is probably not a matter entirely of suppression. Seedlings are very apt to rot in damp situations during the rainy season, and in moist weed-growth the mortality from this cause is high. Drip from overhead trees is also the cause of high mortality among seedlings, and possibly this may also be connected with rotting owing to excessive damp.

SILVICULTURAL CHARACTERS. The soil requirements of the teak have already been described; briefly stated, the tree is capable of thriving on a variety of soils and geological formations, but requires good subsoil drainage. Teak is a pronounced light-demander; it will not tolerate suppression at any period of its life, and requires complete overhead light as well as a fair amount of side room for its proper development. Saplings are often found growing under the light shade of bamboos, and even to some extent under other trees, but the growth of such plants will generally be found to be slower than that of plants with complete freedom overhead. Saplings growing under bamboos and endeavouring to make their way through them will often be found to have their leading shoot damaged or killed, the bamboo acting as a 'whip'; the leading shoot of the teak is very intolerant of any irritation of the kind.

The teak produces a large deep root-system. At first a long thick taproot is formed; this may persist or may disappear, but in either case strong lateral roots are produced. Teak planted in the Andamans in exposed places suffers from the effects of wind, which causes a branchy growth; it requires to be planted in sheltered places, belts of forest being left as screens.

Teak is sensitive to frost, seedlings and coppice-shoots being particularly liable to injury; it resists frost better than some of its associates, however, and has good power of recovery. In its natural habitat severe frosts seldom occur, but the abnormal frost of 1905 did much damage in parts of the Peninsula, poles being killed at the top or down to ground-level; experiments carried out for five years subsequently showed that trees badly damaged by frost were capable, when coppiced, of producing vigorous stool-shoots. Teak is also sensitive to drought. In the abnormal droughts which have occurred from time to time in the Peninsula it has usually suffered more severely than any other species, trees as well as coppice-shoots being killed or hopelessly injured in large quantities.

Teak has greater power of resisting the effects of fire than the majority of its associates. It is true that on steep hill-sides and on ground covered with a dense growth of inflammable grass the damage done by fire to teak trees in all stages is considerable, and it is not improbable that in such places much of the hollowness observable in the lower parts of the boles is attributable to the effects of past fires. Looked at from a comparative standpoint, however, it is equally certain that in burnt areas the survival of the teak as a species is encouraged at the expense of its less fire-resistant competitors. The question of the effect of fire and fire-protection on the natural reproduction of teak is one quite apart from the effect of fire damage on the growing stock, and is discussed below under 'natural reproduction'. Under certain conditions fire may have a beneficial influence in effecting a natural cutting-back process in the case of injured or weakly saplings. Thus Mr. C. B. Smales [1] has recorded

[1] Notes on a Tour in Forests on the West Slopes of the Pegu Yoma, 1917.

some interesting observations on the quality of teak saplings in fire-protected and unprotected forests of a dry type in the Zigôn and Thayetmyo forest divisions of Burma. In the protected forests most of the saplings were forked and many were crooked, while many suffered from injury by wind, temporary suppression, and other causes, and had wounds which persisted. In the unprotected forests such weakly shoots were removed by fire, and the shoots resulting from the regrowth were nearly always remarkably clean and vigorous, defying fire and all competitors.

An unexpected result was obtained in an experiment commenced in the Bhamo district, Upper Burma, in 1900. Two plots of forest were selected near each other; the growth on either was similar, consisting of numerous young teak trees with bamboos (*Cephalostachyum pergracile* in flower and *Dendrocalamus membranaceus*) and *thekké* grass (*Imperata arundinacea*). One plot, 6 acres in extent, was then fire-protected continuously after 1900, while the other, 5 acres in extent, was allowed to burn each year. By 1908 the condition of the plots was totally different. In the fire-protected plot there was a dense mass of bamboos, while in the burnt plot there were scarcely any. Measurements of about 100 teak stems in each plot showed a girth increment 43 per cent. greater in the burnt than in the fire-protected plot, the explanation being that in the former the crop was kept more open than in the latter, in which a dense growth of bamboos and inferior species was encouraged, to the detriment of the development of the teak trees. This experiment can hardly be regarded as conclusive in itself, but similar experiments in other localities might throw more light on what may prove to be a question of some importance.

Teak is not so readily browsed as most of its companions, and resists the effects of grazing better than they do. Mr. J. W. Best[1] alludes to a stunted and shrubby growth in heavily grazed areas in the Bhandara district, Central Provinces, but this is attributed to the hardening of the soil by continued trampling rather than to actual browsing. Heavy grazing may be decidedly harmful in young coppice areas, as the coppice-shoots are soft and easily broken or trampled down by cattle.

In resisting the effects of mechanical injury of any kind the teak shows remarkable vitality. In village forest lands in the Indian Peninsula the last remnants of a former forest are often represented by a scrubby growth of teak, the last surviving species in the process of lopping, cutting, burning, and grazing. On annually cleared fire-lines, again, teak coppice-shoots persist longer than those of most other species. In some localities teak owes its survival in part to the fact that as a 'royal tree' it has received special protection for a long period of years, but apart from this it owes its prevalence in many places where it constitutes the bulk of the growing stock to its great power of resistance to the effects of hacking, burning, and grazing.

Teak suffers from various forms of injury by animals. In the Peninsula rats multiply in certain years and do considerable damage in plantations by gnawing the roots. Pigs also do much damage in some parts of the Peninsula by rooting up seedlings, particularly in plantations, where the newly-dug earth attracts the animals. In Burma much damage is done in some localities by

[1] Ind. Forester, xxxv (1909), p. 613.

saing (*Bos sondaicus*), which strip off the bark from teak poles and often kill them outright. This form of damage is also perpetrated by bison and sometimes by deer. Of all wild animals, however, the elephant is the worst offender, his depredations being noticeable to some extent in Malabar and on a larger scale in Burma. The damage consists of breaking down or uprooting poles, especially in plantations, which may be utterly ruined, and of stripping the bark off trees. The latter form of damage is done by digging the tusks under the bark, tearing it open, and then pulling it off in long strips. The bark is often stripped off completely round the lower parts of the trees, many of which are killed, while, if they survive, the wounds caused by the barking may admit fire and rot. Mr. G. R. Jeffery [1] estimated that in the Wapyudaung working circle, Ruby Mines district, about 90 per cent. of the unsound trees in the moister types of forest owed their unsoundness directly or indirectly to damage by wild elephants, and concluded that it would be impossible to grow sound teak in forest infested by these animals.

Teak is subject to various insect attacks, perhaps the most serious of which is that of the larva of *Duomitus ceramicus*, Wlk., a moth, which bores into standing trees in Burma and causes the large holes erroneously termed ' bee-holes '. Another lepidopterous borer, *Cossus cadambae*, Moore, does much damage in Travancore. It tunnels down the interior of young stems one to two years old, and the only remedy is to cut back the stems ; it also gains admission through the wounds caused by lopping branches of trees for manure. Of defoliators, the commonest are the caterpillars of *Hybloea puera*, Cram., and *Pyrausta machaeralis*, Wlk. The former consumes the whole leaf except the midrib and the main lateral veins, while the latter skeletonizes the leaves, eating the parenchyma and leaving all the veins. Another defoliator is the caterpillar of *Paliga damastesalis*, Moore, the ' teak-leaf roller ', which, though more local, does a considerable amount of defoliation in some localities, particularly on dry hill-sides.

The fungous pests of the teak have not been studied in any detail. In Upper Burma the existence has been recorded of a thread-like blight on teak leaves and of a fungus in the plantations of Katha which arrests the growth of the leading shoot, causing a nest-like formation ; cutting back has been found effective in the case of the latter fungus. In the Gwethe reserve of Toungoo in 1911–12 a group of teak trees 5 to 7 ft. in girth was found to be attacked by a fungus, which had killed some of the trees ; specimens were examined at Pusa by the Imperial Mycologist, who reported great destruction to the woody elements by a fungus which appeared to be strongly parasitic, but without the sporophores the fungus could not be identified. A mildew, *Uncinula Tectonae*, Salmon, which attacks the leaves of the teak and of *Cordia Macleodii*, appears to be fairly widespread in the Central Provinces. Mr. A. L. Chatterji [2] notes that it attacks only the upper surface of the leaves, giving them a characteristic bluish appearance. The fungus does not appear to do any material damage.

In some localities teak suffers from the attacks of *Loranthus*. This parasite was at one time troublesome in the Nilambur plantations, but branches

[1] Working Plan for the Wapyudaung Working Circle, Ruby Mines Forest Division, 1911.

[2] Ind. Forester, xxxviii (1912), p. 28.

attacked by it have been systematically lopped, and it has thus been kept in check.

Teak coppices and pollards vigorously, and sometimes retains the power of coppicing to a considerable size. Mr. Foulkes[1] mentions a tree in North Malabar with a breast-height girth of 97 in., which when felled produced 22 coppice-shoots, and stems with *diameters* of 2 ft. 10 in. to 6 ft. 4 in. which produced 11 to 13 shoots per stool. The early growth of coppice and pollard shoots is rapid. Of twelve different species coppiced and pollarded experimentally in 1909 in North Chanda, Central Provinces, teak showed the most rapid growth both of coppice and of pollard shoots. Mr. J. C. Legge[2] records measurements of coppice-shoots from stems five years old cut back in plantations in Travancore on February 14–17. These were measured on May 11, when less than three months old, and were found to vary from 3½ to 7½ ft. in height, the number of shoots per stool varying from 7 to 23: an unusual fall of 10 in. of rain, however, occurred at the time of cutting back. An average height of 7 to 10 ft. for coppice one year old is not unusual.

An experiment carried out in 1906 in the Jubbulpore district, the object of which was to ascertain the most favourable season in which to carry out coppice fellings, has been described by Mr. R. S. Hole.[3] Trees 2 to 4 ft. in basal girth, selected for equal vigour and similar conditions of environment, were coppiced in different months from March to September. The stools were cut flush with the ground. The best results were obtained in March and September, and the worst results, with reference to three different factors, were obtained as follows:

Factor.	Months giving worst results.
Total and partial failure to coppice	April, May, June, July.
Number of dominant stems	June, July, August.
Height growth	July, August.

Thus the worst period for coppicing was found to be from the time vegetative activity commences—it was abnormally early that year—up to and for a short time after the full development of the foliage. In the course of this experiment it was found that in the case of the larger stools, with 3–4 ft. girth, the number of vigorous shoots per stool was greater than in the case of the smaller stools, with 2–3 ft. girth. The following are the figures:

Girth of stool.	Average number of vigorous shoots per stool according to month of felling.						
	March.	April.	May.	June.	July.	Aug.	Sept.
2–3 ft.	1·7	2·0	1·8	1·6	1·9	1·6	2·4
3–4 ft.	4·0	3·8	2·5	2·1	2·0	2·2	2·7
Average of all sizes (2–4 ft.)	2·3	2·6	2·3	1·9	1·9	2·0	2·5

All the coppice-shoots originated in one of two ways—(1) from callus growth developed inside the bark and situated between the bark and the wood at the edge of the cut surface, or (2) from the side of the stool below the cut surface, the shoots appearing through the bark. The former, which may be

[1] Ind. Forester, xl (1914), pp. 262, 263. [2] *Ibid.*, xxiii (1897), p. 205.

[3] Note on the Best Season for Coppice Fellings of Teak, For. Pamph. No. 16, Bot. Ser. No. 1, 1910.

termed 'callus shoots', are of adventitious origin, while the latter, which may be termed 'side shoots', probably arise from dormant buds. Mr. Hole notes that high coppicing appears to prevent the formation of callus shoots owing to the rapid drying and shrinking of the wood at the cut surface, causing separation from the bark: also that, subject to further confirmation, present evidence seems to show that it is best to coppice teak low shortly before the commencement of vegetative activity, when as little of the dry season as possible remains, or if felling must be done in the season of rest, high felling may possibly be preferable, so that the base of the stump will still remain alive if the upper part dies.

It is stated [1] that observations in the Melghat, Berar, have indicated that in the case of old teak stumps whose vitality is poor it is better to leave stools 4 or 5 in. high than to trim them flush with the ground, as in the latter case the dormant buds appear to be cut away.

Experiments carried out in 1909 in North Chanda to some extent corroborate the Jubbulpore experiment as regards the season for coppicing teak. Stools coppiced in successive months from April to September showed the following percentage of success in producing shoots: April 100, May 100, June 92, July 91, August 40, September 71.

There is little doubt, from observations made in localities where felling or coppicing has been carried out for a long series of years, that teak stools retain their vitality for a considerable time, and also, particularly in the case of old hollow stumps cut flush with the ground, that the coppice shoots may develop independent roots of their own, and may have the external appearance of independent plants, until a search below the surface of the ground reveals the fact that they are connected by the periphery of the old stump. In some cases this connexion may possibly disappear in course of time.

The question whether or not teak produces root-suckers has been the subject of some inquiry. In his account of teak in the Wynaad, North Malabar, Mr. G. F. Foulkes states: [2] 'Where free seedling reproduction is absent the tree reproduces itself from coppice-shoots and more chiefly from root-suckers. This is the case at the present time not only in the Wynaad but throughout the teak areas of the Madras Presidency.' The statement that teak reproduces from root-suckers, which is reiterated elsewhere in the same article, evolved some comment from Forest Officers in other localities, and an inquiry was accordingly instituted with the view of ascertaining to what extent the production of root-suckers is a general characteristic of the teak. A search was made for root-suckers in different provinces and localities, including North Malabar, and reports and specimens were sent to Dehra Dun. As a result of this inquiry Mr. E. Marsden [3] contributed a paper summarizing the conclusions arrived at. An examination of the various specimens received, which included specimens from North Malabar, revealed certain characteristics common to all, namely:

'(i) The "root-suckers" are close to each other or to the parent stem (usually not so far that their point of attachment to the "root" could not have been reached by a buttress or a lateral extension of the stem).

[1] Annual Forest Administration Report, Berar Circle, 1913–14.

[2] Ind. Forester, xl (1914), p. 192.

[3] *Ibid.*, xlii (1916), p. 43.

'(ii) The "roots" are damaged or eroded on the upper side.

'(iii) The roots are near the surface.

'(iv) The parent stem is generally decayed.'

Now the vitality of teak stumps is remarkable; trees which have been coppiced at times send up stool-shoots low down on the stool at the base of the buttresses which are the upward continuations of the main lateral roots. The centre of the original stool may die and in time decay or become burnt, but the stool-shoots remain alive and may form independent root-systems, though they may remain connected by the periphery of the original stump. If these coppice-shoots are in their turn felled, new shoots may be produced on the side away from the original stump: the subsidiary stumps from the second coppicing may in their turn die and decay or become burnt, the result being a group of shoots apparently arising from lateral roots, and in some cases connected together by the root-like living periphery of an old stump, the interior of which has disappeared. Such was evidently the origin of the various specimens of 'root-suckers' received at Dehra Dun, none of which appear to have arisen otherwise than in close proximity to the parent stem.

The following extract from a paper by Mr. E. E. Fernandez [1] on the production of shoots by teak trees in the Central Provinces throws considerable light on the question of root-sucker production by teak:

'To ascertain whether these shoots were true suckers, or merely one of the many instances of ordinary shoots that spring up more or less in contact with the parent stool, the following experiments were carried out:

'1. I had the soil dug up round eight trees, which I then cut down below the level of the ground. In two out of the eight cases, just enough of the stem was left to keep the principal roots connected. In the rest the stem was quite cut out, separating these roots entirely from each other; along with the stem a less or greater portion of the root was, of course, removed. The earth with chips of wood was then thrown back. All the trees were over 80 years old, three of them hollow and decaying.

'2. I wounded the exposed portions of the principal roots of upwards of 100 trees. In some cases a chip of bark only was taken off with a sharp axe, in others a portion of wood was also removed; some of the wounds were made with a blunt instrument, others with a stone, and so on. A considerable number of wounds were more or less covered over with fine earth, or ashes, or cow-dung.

'3. Similar wounds were made in the underground portions of many principal roots, and lightly covered over with soil.

'4. And lastly, I dug up carefully the extremities of some principal roots and covered most of them up lightly with soil, leaving some in their natural position, others slightly bent upwards, to favour the production of suckers, if any were likely to come up.

'Of the eight trees exploited underground, five threw up shoots the following rains, among these the two in which a portion of the stem was left. These latter, it must be noticed, produced the greatest number of shoots. In the three other successful instances the shoots sprang up from, or close to, the section of the roots; the three cases of failure were those in which the largest portions of the principal roots were cut away with the stem. Making allowance for differences of soil, the strongest shoots were produced by those which had lost the least portion of their principal roots. Experiments 2, 3, and 4 were complete failures; moreover, an inspection of over 5,000 stools

[1] Forest Conference, Simla, 1876.

coppiced did not show a single shoot that had not sprung up in contact with the stools. Besides this, on many occasions when I have met with young teak plants that from their position to trees near them looked like suckers, I have had them carefully dug round and have invariably found their roots entirely distinct from those of the suspected parent trees.'

So far as direct evidence goes at present, then, it may be said that teak does not possess the tendency to throw up true root-suckers at a distance from the parent stem, and that the so-called 'suckers' which spring from low down on the stump, at its junction with the main lateral roots, although they may in certain cases bear a close resemblance to true root-suckers, should more correctly be regarded as stool-shoots. True root-suckers, such as those of *Dalbergia Sissoo, Butea frondosa, Oroxylum indicum*, and many other trees, if they are produced by the teak, must be of rare or local occurrence.

NATURAL REPRODUCTION. The natural reproduction of teak has been the subject of numerous experiments and observations which enable us to arrive at certain conclusions regarding the effects of various factors, favourable or otherwise, which bear on it. Our knowledge of the subject, however, is by no means complete, and much detailed research still remains to be done. The factors influencing natural reproduction may be considered under three heads: (1) spread of seed, (2) factors influencing germination, and (3) factors influencing the survival and development of the seedling.

(1) *Spread of seed*. Under natural conditions the fruits begin to fall in the cold season, about December or January, and continue falling during the ensuing hot season. On more or less level ground they fall and remain under and around the trees until, if conditions are favourable, germination takes place. On hill-sides where there is an insufficient soil-covering of grass or other plants to hold them up, many fruits are washed down the slopes early in the rainy season. The chief transporting agency of teak seed is water, and this accounts in part for the fact that teak often springs up gregariously on alluvial flats, whither the fruits are conveyed in the season of floods and deposited in quantity.

(2) *Factors influencing germination*. Given a sufficient degree of moisture, the chief factor influencing germination is temperature; soil-aeration is a probable factor, while certain other factors are brought into play in connexion with the burying of the seed.

(i) *Temperature*. A temperature sufficiently high to induce ready germination may be produced either by the heat of the sun or by fire. In cool shady places teak seed germinates with difficulty or not at all, and may lie dormant for years, eventually germinating in quantity as soon as the direct rays of the sun are admitted to the ground by the opening of the canopy and the clearing of undergrowth. This is amply demonstrated by the regenerative operations in the Mohnyin forest described on p. 752 and by some of the examples quoted below. Mention may also be made of an experiment carried out by Mr. Hole at Dehra Dun.[1] Seed was sown on July 2, 1913, in two adjacent plots, one open to the sun and rain, the other completely shaded from the sun but receiving all the rain which fell: the percentage of germination was 17 in the former and 1 in the latter. After two years the open plot

[1] Ind. Forester, xlii (1916), p. 51.

was full of vigorous seedlings, but of the few seedlings which germinated in the shaded plot none survived. The shade over the latter was removed on June 28, 1915, and the admission of the sun's heat was at once followed by the germination of a number of seeds which had lain dormant for two years. Numerous instances have been recorded in the forest of teak seedlings appearing in quantity where the canopy has been opened; some of these are quoted below. Germination is greatly stimulated if the seed lies in the open exposed to a thorough baking by the sun during the hot season, and to the alternate soaking and heating which it experiences during the early showers preceding the monsoon proper. Germination then takes place chiefly at the beginning of the monsoon, though in some cases it may continue throughout the greater part of the rainy season. A case of failure of seed to germinate when lying in an area shaded laterally is described below (p. 722).

The beneficial effect of fire in stimulating the germination of teak seed is now thoroughly realized in Burma. Experiments which I carried out in that province in 1903 and 1904 showed that slight scorching, such as would occur in a light leaf fire, stimulates germination, but that severe scorching, amounting to charring of the fruits, destroys the vitality of the seed; the latter condition is produced by the firing of a thick layer of leaves or of a somewhat heavy growth of grass. Under natural conditions the fruits fall partly before and partly after the season of fires, and in burnt forests it is probable that a portion of the seed-crop is destroyed by fire while a portion has its germination stimulated by fire, the net result depending a good deal on the nature of the soil-covering. In the case of seed lying dormant in the ground, fire undoubtedly has a stimulating effect on germination, as various experiments in Burma in cutting and burning the undergrowth have shown. The measures now adopted in Burma for securing natural reproduction are described in detail on p. 755; it will be seen that thorough burning is regarded as essential to success. The beneficial action of fire is probably connected not only with the heat produced by it, but also with its action in clearing and aerating the ground. An experiment in Coorg [1] may here be referred to, in which the undergrowth below twelve trees was burnt in the hot weather of 1908, with the result that a large number of natural seedlings sprang up, of which only 184 survived the drip from the mother trees during the subsequent monsoon.

(ii) *Soil-aeration.* In the experiment referred to above, Mr. Hole demonstrated that an admixture of dead teak leaves in fairly heavy loam was beneficial to germination when the soil was kept well aerated and fully exposed to light and air, but was injurious when kept constantly wet. In my experiment at Tharrawaddy, described below, the beneficial effect of hoeing the soil is clearly shown. Further experiments, however, are necessary to determine the precise effects of soil-aeration under different conditions.

(iii) *Burying of the seed.* Experiments at Dehra Dun, which were repeated several times, showed that seed lying on the surface of the ground exposed to the sun almost invariably fails to germinate owing to the fact that the radicle dries up or is eaten by insects or birds before it penetrates the soil; the drying up of the radicle is particularly liable to occur on hard ground.

[1] For. Admin. Report, Coorg, 1907–8.

Actually on bare ground teak seed becomes buried naturally in a remarkably short space of time. Rain is the chief agent in burying the fruits, but white ants frequently devour the outer felty covering, leaving the inner hard nut intact, and these insects no doubt assist in burying them. In experimental plots at Dehra Dun a quantity of fruits scattered on bare ground in February had almost all become buried before the end of July: on grass-covered ground they remained for the most part on the surface uncovered, but here germination was moderately successful owing to the protection from the sun which the grass afforded during the process. The beneficial effects of loose soil are due in part to the fact that it facilitates the burying of the fruits. A covering of half an inch or less is quite sufficient, seed buried deeper germinating more tardily.

(iv) *Combinations of factors.* An experiment which I carried out at Tharrawaddy, Burma, in 1904, throws some light on certain combinations of factors influencing the germination of teak. Eight adjacent plots were marked out in the open, exposed to the full effect of the sun's heat and light. In each plot 100 teak seeds, not treated in any way, were sown. In six of the plots, which may be termed A, sowing was carried out on April 13, that is, before the first showers, and in the remaining two plots, which may be termed B, sowing was carried out on June 23, that is, after the monsoon had well set in. The method of preparation of the plots and the results of the germination were as follows:

Tectona grandis: results of germination experiments, Tharrawaddy.

Method of preparation of soil and sowing of seed.				Percentage of seeds which germinated up to date. June 18.	June 24.	July 17.
A. Sowing carried out on April 13.						
Area burnt; about 3 in. layer of leaves	Soil not prepared	Seed sown broadcast and not covered	(1)	26	27	28
	Soil loosened with hoe	Seed sown broadcast and not covered	(2)	32	43	47
		Seed sown broadcast and lightly covered	(3)	67	75	81
Area not burnt; sparingly covered with dry short grass at time of sowing	Soil not prepared	Seed sown broadcast and not covered	(4)	*Nil.*	8	11
	Soil loosened with hoe	Seed sown broadcast and not covered	(5)	19	21	25
		Seed sown broadcast and lightly covered	(6)	42	42	44
B. Sowing carried out on June 23.						
	Soil not prepared	Seed sown broadcast and not covered	(7)	No germination took place throughout the rains: even had it done so the young plants would have had a harder struggle against weeds than those in plots A.		
		Seed placed in shallow holes and lightly covered	(8)			

Although a single experiment of this kind cannot be regarded as conclusive, yet it confirms results obtained in other experiments, and indicates: (1) that germination is greatly stimulated if the seed lies exposed to the sun from before the commencement of the early showers preceding the monsoon,

and that without this early exposure it may fail altogether during the first year, even in the open; (2) that the best results are obtained by burning the soil-covering, hoeing up the soil, and lightly covering the seed; (3) that the worst results are obtained in the case of seed lying uncovered on ground neither burnt nor loosened.

In this experiment it was noticeable that the seedlings made the best start and the weed-growth was retarded most on ground burnt and hoed, while on ground not burnt but hoed up conditions were nearly as good. Weed-growth was most plentiful on the plots which were neither burnt nor hoed up; on these a tall growth of grass and weeds sprang up early, and by July had begun to kill out the seedlings.

(3) *Factors influencing the survival and development of seedlings.* So far as is known the chief factors influencing the establishment of natural reproduction are (i) light, (ii) soil-aeration, (iii) soil-moisture, (iv) weed-growth, (v) grazing, and (vi) fire.

(i) *Light* is one of the most important factors in the establishment of natural reproduction, the teak being a strong light-demander from its earliest youth. Although saplings may persist for a time under the light shade of bamboos and other overhead cover, their development is slow and they become readily suppressed. Experiments carried out within recent years in Pyinmana and Prome have shown that a sudden influx of light to badly suppressed teak saplings, far from causing their recovery, may cause their death. The admission of light by the opening of the overhead cover is the main object of so-called improvement fellings for the benefit of the young crop in natural forest. In Burma, where bamboos play such a prominent part in the composition of the forests, excellent teak reproduction is often seen in areas where elephants have been herded for some time in connexion with timber extraction; these animals perform a useful service in breaking down the bamboos and admitting light and warmth to the ground, with the result that teak seedlings sometimes spring up and establish themselves in a manner suggesting a well-stocked plantation. At the same time elephants, if kept longer than is necessary in such areas, may undo the good they have done owing to their propensity for damaging young teak poles. Intensive bamboo exploitation has a similar effect in stimulating teak reproduction. Again, along the sides of dragging-paths, on fire-lines and in other openings through the forest, natural reproduction tends to spring up freely (see Fig. 274). Along the sides of dragging-paths and where exploitation has been in progress the breaking up of the soil no doubt also acts favourably, apart from the admission of light. Mr. R. Bourne has noted an interesting case of the adverse effect of side shade in one of the Nilambur plantations. Part of the Aravillicava plantation was clear-felled in 1917, and natural reproduction sprang up in quantity in July; in places the seedlings were so dense that it was hardly possible to step without treading on them. This clear-felled area had already been planted up the previous month and the new plantation was weeded without damaging the natural seedlings. In this clearing were two areas on which shade was cast for a considerable period in the morning by the adjoining plantations, which were 90 to 110 ft. high. Here not only did no natural seedlings spring up within the area shaded after 8 to 9 a.m., owing to the temperature necessary for germina-

tion being insufficient, but the planted seedlings showed markedly poorer growth in that area than they did in the open. On the edge of the clearing the drip from the overhanging trees in the adjoining plantations certainly affected the young plants; but in the shaded areas the breadth affected and devoid of all natural reproduction was in places as much as 130 ft., and it is therefore beyond question that the absence of natural reproduction and the inferior growth of the planted seedlings were the direct result of the lateral shade.

(ii) *Soil-aeration* is a term which may for the present be applied, for want of a better one, to certain conditions which have a marked effect on the establishment or failure of natural reproduction. Under this head may be included the tendency of teak seedlings to rot in excessively moist or water-logged situations, and where damp weed-growth exists; the mortality from this cause during the rainy season may be very high. The wholesale death of seedlings during the rainy season owing to the drip from overhead trees may possibly be attributable, in part at least, to the same cause. It has sometimes been attributed to some toxic effect in rain water falling from teak leaves, but this is mere conjecture. Whatever the precise nature of the adverse influence may be, it is a well-known fact that seedlings are killed off in large quantities by the drip from overhanging trees, and that anything short of complete clearance of the overhead canopy is liable to result in high mortality among teak seedlings in forest at all approaching a moist type. The aeration of the soil by loosening has a marked effect on the development of young plants, and in dry localities it is a useful means of stimulating a strong and healthy growth which enables seedlings to survive drought. In the experiment alluded to above, Mr. Hole found that an admixture of dead teak leaves in fairly heavy loam was beneficial to the growth of teak seedlings when the soil was kept well aerated and fully exposed to light and air, but was injurious when kept constantly wet. The vigorous growth of teak seedlings on the sites of old charcoal kilns and on patches of burnt débris is probably attributable to the aeration of the soil in such places. Soil-aeration plays an important part in the establishment of seedlings under the system of mulching described in the next paragraph.

(iii) *Soil-moisture.* Deficiency of soil-moisture is one of the greatest obstacles to the establishment of natural reproduction in many parts of the Indian Peninsula, particularly in forests of a dry type. Seedlings often appear in quantity at the beginning of the monsoon, but have to contend against weeds during the rainy season, with the result that those which survive the struggle are weakly plants, which succumb to drought during the ensuing dry season. Any measures which will tend to promote vigorous growth during the early life of the seedling are likely to aid it in surviving the effects of drought, and the measures first tried with success by Mr. W. E. Copleston in the Haliyal teak pole forests in the drier parts of the Kanara district and now adopted in other parts of Bombay, have proved to be an effective method of securing the survival of natural seedlings in localities where under ordinary circumstances they are liable to perish from drought. The survival of the seedlings is secured by a system of surface mulching. The mulch consists of a small armful of green twigs with leaves, grass, or even dead material, the refuse of the fellings, spread in a ring round the plant; on this

are thrown two or three spadefuls of earth. According to Mr. Copleston,[1] the soil round the plants is not loosened, and the two main objects of the mulch are (1) to keep the soil round the plants free from weeds, for which purpose a six-inch layer of grass and leaves, with a very little soil to keep them in their place, is sufficient to keep the ground clean for a whole year; (2) to secure the loosening and aeration of the soil by worms and insects, for after the mulch has been down a month in the monsoon a mass of worm-casts and much tunnelling by insects may be found under it. The class of forest to which this system of mulching is applied is thinly stocked pole forest of teak on dry, hard, stony ground; the rainfall is only about 30 in. The results are remarkably good, for in coupes where formerly no seedlings survived it is possible to establish from 200 to 300 per acre at a cost of between Rs. 3 and Rs. 4 per acre. This method of tending natural seedlings has recently been tried in the Melghat, Berar; in open places the results were good, but where there was any drip from overhanging trees the seedlings failed to survive.

(iv) *Weed-growth.* The intolerance of teak seedlings to suppression by weeds has already been alluded to under 'the seedling'; weed-growth is one of the most serious obstacles to the establishment of natural reproduction, which in areas where weeds are prevalent can be secured in quantity only by means of systematic weedings commenced in the first rainy season and continued regularly until the plants are free from the risk of suppression.

(v) *Grazing.* If not heavy, grazing appears to favour the reproduction of teak rather than otherwise, by keeping down heavy grass and undergrowth. Experiments were carried out in 1914 in the Wardha district, Central Provinces, in which cattle were admitted into coppice coupes which had been closed to grazing for three years after felling. This resulted in little or no injury to the teak coppice or seedlings, but one year's grazing stimulated such a rank growth of *Cassia Tora* and *Indigofera glandulosa* as to threaten further teak reproduction.

(vi) *Fire.* In the drier types of teak forest, such as those met with throughout a considerable part of the Indian Peninsula, fire is admitted to have an adverse influence on the establishment of teak reproduction, which is greatly assisted by fire-protection. In many of the moister types of forest, on the other hand, it has now been proved beyond doubt that indiscriminate fire-protection exercises an adverse influence on teak reproduction by encouraging the growth of inferior species, bamboos, and dense undergrowth at the expense of the more fire-resisting and light-demanding teak. We are not concerned here with the question of damage done by fire to the standing crop, or to the effect it is sometimes held to have in impoverishing the soil; nor are we concerned with the effect of fire-protection on the drier types of forest, but only with its effect on the moister types of teak-bearing forest constituting most of the best teak areas in Burma and along the Western Ghats. In the latter region the adverse effects of continued fire-protection in the moister types of teak forest have been noticed for some years past, but the matter has received more attention in Burma than elsewhere owing to the large extent and the great importance of the moister types of forest, where the teak reaches its best development.

[1] Ind. Forester, xlv (1919), p. 82.

FIG. 274. Natural reproduction of teak along old dragging-path, Pyinmana, Upper Burma.

Fig. 275. Forest of *Bambusa polymorpha*, never fire-protected, with natural reproduction of teak on the ground, Tharrawaddy, Burma.

Fig. 276. Dense young growth of *Cephalostachyum pergracile* under *Bambusa polymorpha* in forest which has been fire-protected for 14 years, Tharrawaddy, Burma.

In Burma the precise effects of annual burning and of continuous fire-protection on the condition of the forest and the undergrowth are easy to observe. Where, as is usual, bamboos form as it were the matrix of the forest, fire-protection has the effect of greatly increasing the luxuriance of the bamboo growth, so much so that the establishment of teak seedlings, even if germination were possible, is out of the question. Figs. 275 and 276 respectively show typical forest of *Bambusa polymorpha* and *Cephalostachyum pergracile*, the former never fire-protected and containing teak reproduction, and the latter successfully fire-protected for fourteen years, during which time so dense a growth of bamboo has taken possession of the ground that teak reproduction is quite unable to establish itself. Longer periods of fire-protection show even greater changes, and in many cases the forest becomes converted from a deciduous to an evergreen type by the encouragement of sensitive evergreen shade-bearers. In annually burnt teak forests of the type under consideration the seedlings, it is true, may be burnt back year after year, meanwhile developing thick root-stocks, but their wonderful power of recovery enables them to survive, and even to gather strength with each successive burning back, until eventually the time comes when the seedlings are able to survive the burning and to establish themselves as strong healthy plants.

The desirability of extending fire-protection throughout all classes of teak-producing forest in Burma was first called in question by the late Mr. H. Slade in 1896.[1] The interest in the matter which was thus awakened resulted in a mass of evidence being collected, the great bulk of which affords ample proof that in the moist types of teak-bearing forest indiscriminate fire-protection is detrimental to, and may entirely prevent, the natural reproduction of teak, and that if it is continued it is likely to result in the total disappearance of teak throughout large areas of the most important class of teak-bearing forest in Burma. The recognition of this fact has resulted in the abandonment of fire-protection over considerable areas where its results are known to be detrimental to the reproduction of teak. It may be of interest here to examine some of the evidence which has led to this step being taken.

The first actual enumerations made with the view of comparing the stock of young teak trees in fire-protected and burnt forest respectively appear to have been those which I carried out in 1905 in two adjoining plots, one inside and the other outside the external fire-line of the Kadinbilin reserve in Tharrawaddy.[2] The former plot, 37 acres in area, had been successfully protected from fire for thirty-two years, and the latter had never been fire-protected. The plots were typical of the usual moist mixed forest of the Pegu Yoma, the bamboos being *Bambusa polymorpha* and *Cephalostachyum pergracile*. Prior to the introduction of fire-protection, both plots must have been precisely the same in appearance and character; at the time of the enumeration, however, prolonged fire-protection had greatly increased the density of the bamboos in the protected plot. There was a sufficiency of teak seed-bearers in both plots to secure ample reproduction under favourable conditions. In both plots bamboo extraction had been carried on for many years, and in the fire-protected plot improvement fellings had been carried out twice, and dibblings of teak seed had been made. Everything therefore favoured a plentiful crop of young

[1] Ind. Forester, xxii (1896), p. 172. [2] *Ibid.*, xxxi (1905), p. 138.

teak in the protected plot, had conditions for its establishment been favourable. The enumerations revealed the following number of teak poles, saplings, and seedlings in each plot:

Tectona grandis: enumeration of natural young teak in fire-protected and unprotected plots, Tharrawaddy.

Class.		Number calculated for 50 acres in each case. Fire-protected plot.	Unprotected plot.
I. Poles 1 ft. to 2 ft. in girth	(a) Sound	174	135
	(b) Unsound and dead	109	29
II. Poles and saplings under 1 ft. in girth	(a) Sound	24	141
	(b) Unsound and dead	121	37
III. Seedlings		62	616

These figures reveal the fact that although the larger poles, which had established themselves prior to the days of fire-protection, were more numerous in the protected than in the unprotected plot, the seedlings—many being young plants which had been burnt back for some years and were only establishing themselves by degrees—were ten times as numerous in the unprotected as in the protected plot. A striking fact, which was wholly unexpected, was the large proportion of unsound and dead saplings and poles in the protected as compared with the unprotected plot. This was due to suppression by the bamboos; in the unprotected plot weakly stems had to a large extent been killed back by fire and replaced by strong regrowth. In the protected plot the proportion of poles killed outright by suppression amounted to about 75 per cent. of the total number of suppressed and dead stems, and the remainder were so badly suppressed that there was no hope of their ever recovering. In the unprotected plot the sound poles were vigorous, bore no sign of fire damage, and had little to fear from future suppression, the bamboo clumps having been kept well apart by the annual burning; the unsound and dead poles appeared to have suffered not from fire but from suppression in places where the bamboo growth was particularly luxuriant.

These enumerations give some idea of the holocaust of young teak plants which takes place in typical moist mixed teak forest in Burma as a result of prolonged fire-protection. Unwilling to accept the figures as conclusive, I appealed at the time for further evidence as to the effects of fire-protection in different localities, and such evidence has been forthcoming. In 1907 Mr. F. Beadon Bryant recorded the results of enumerations made in 1906 in various working plan sample plots, aggregating 275 acres, in the Tharrawaddy forests. These plots had previously been enumerated when the working plans were prepared twenty-one years before; some of them had meanwhile been fire-protected for many years, others had been protected for a few years, and one had not been protected at all. Mr. Beadon Bryant's results confirmed those yielded by my enumerations, namely that prolonged fire-protection results in a marked decrease in the number of young teak trees in forests of the moist mixed type.

Similar re-enumerations have since been carried out in various parts of Burma, and the results have been recorded mainly in forest administration

reports. The figures so recorded do not always appear to be based on sufficiently comprehensive *data*, but there is enough reliable evidence to confirm in no uncertain manner the conclusions previously arrived at, to the effect that prolonged fire-protection in the moist types of teak forest is detrimental to the establishment of teak reproduction. As an indication of the adverse effects of fire-protection in certain of the forests of the Ruby Mines district, the following extract, which describes the condition of things after seven or eight years of successful fire-protection, may be quoted from the working plan of the Maingtha, Kunchaung, and Nanme reserves :[1]

'The effect of fire-protection here is that the undergrowth, naturally very dense and consisting largely of evergreen species, is rendered still denser : in *wabo*[2] areas it is almost impenetrable, while in *tinwa*[3] areas on high ground, where light enters more freely, a heavy undergrowth of dwarf *tinwa* springs up. The result is that (1) teak seeds lying on a cold bed of decaying vegetable matter do not receive sufficient exposure to light and heat necessary to germination, seedlings are practically non-existent, and no new root-stocks are formed whence shoots may annually endeavour to establish themselves, (2) shoots on old root-stocks are more liable to suppression than they are in non-fire-protected forests. In drawing these conclusions it has been observed that trees grown direct from seedlings are practically never found in either fire-protected or non-fire-protected areas : reproduction consists entirely of shoots on old stocks, some very old, some only a few years old. These shoots are less plentiful in fire-protected than in non-fire-protected areas, but in neither are they common except where breaks in the undergrowth and low overhead cover have been formed, usually by removal of bamboos or groups of teak in semi-evergreen forest. But the most convincing part of the experiment[4] has taken place in the forest in the neighbourhood of Dogyaung, Asugyi, and Kwehaungdon villages, where bamboos have been heavily cut for a great number of years. In this locality, on the one hand, splendid groves of sound small teak trees of a girth of one or two feet may be seen which sprang up as the result of bamboo-cutting in the days when fire-protection had never been thought of ; they are not merely chance groups, as they occur freely over several compartments. On the other hand, although bamboos have been cut just as regularly and probably more heavily during the last eight years since fire-protection was instituted, there are now only a few fair patches of reproduction, and no considerable number of seedlings or stool shoots to be found on corresponding areas ; and they ought to appear in still greater numbers if fire-protection is to be justified.'

These remarks are the more interesting in that the writer, Mr. Walsh, admits having commenced his observations with preconceived ideas 'that correct conservancy of every type of forest included the prevention of fire'.

Although it is now generally agreed that continuous fire-protection is detrimental to, and may entirely prevent, the natural reproduction of teak in the moist types of teak-bearing forest in Burma, our knowledge of the subject is by no means complete. The value of fire-protection in the dry types of teak forest in the Indian Peninsula is fully admitted, and there is in all probability a stage between the moister types and the driest types in Burma in which fire-

[1] Working Plan for the Maingtha, Kunchaung, and Nanme Reserves, Ruby Mines Division, H. L. P. Walsh, 1906.

[2] *Dendrocalamus Hamiltonii.*

[3] *Cephalostachyum pergracile.*

[4] The protection of these forests is described by the writer of the working plan as 'a gigantic experiment which has cost half a lakh of rupees'.

protection ceases to be injurious and commences to be beneficial to the natural reproduction of teak. That stage, however, still remains to be determined.

Some examples of natural reproduction. Prolific natural reproduction of teak often springs up on abandoned shifting cultivation. This is to be seen in certain localities in the Indian Peninsula, notably in the Melghat, and is frequently observed in Burma, where abandoned *taungya* clearings often become covered with a thick and even-aged growth of almost pure teak, in many cases resembling a well-stocked plantation.

The following extract from the annual forest report of Burma for 1915–16, referring to unclassed forest adjoining the Nansaung reserve in the Mansi forest division, describes a condition of affairs often met with under similar conditions in Burma: '*Taungyas* have been freely cut in this excluded portion, and the result has been that wherever the clearings were made the natural regeneration of teak is splendid, and we have patches of teak varying in age from two years to thirty which are as good as some of the best plantations in the Tharrawaddy division, and this without any expenditure at all.'

In Upper Burma the origin of pure even-aged natural crops of teak, other than those on alluvial bends of streams, may in a large number of cases be ascribed to abandoned cultivation, and there is little doubt that the Mohnyin forest of Katha, consisting in places of pure teak of large dimensions, originated on land which went out of cultivation during the conflicts between the Burmans, Shans, and Chinese towards the end of the sixteenth century. The main factors which appear to favour the reproduction of teak on abandoned cultivation are (1) the great vitality of the seed, which may accumulate and remain dormant in the soil for years prior to the clearing of the forest for cultivation; (2) the clearing and burning of the forest and undergrowth and the cultivation of the ground, with the consequent aeration of the soil and the admission of the sun's heat and light, and the eradication of weeds; (3) subsequent annual burning—since these areas are not fire-protected—which favours the teak against competitors.

The remarkable effect of complete clearing followed by weeding, in the stimulation of natural reproduction, is illustrated in the regenerative operations carried out in the Mohnyin forest, and described on p. 752 (see Figs. 287 to 290). At Nilambur the clear-felling of mature teak plantations and the burning of débris are followed by abundant crops of natural teak seedlings which spring from seed lying dormant in the ground.

A remarkable instance of profuse natural reproduction is to be seen in a plantation of teak, mixed in places with sissoo, on well-drained alluvial ground at Ramgarh in the Gorakhpur district, United Provinces. This locality is well outside the natural habitat of the teak, and the trees are not particularly good specimens as regards either size or shape. The plantation was formed in 1873–4, and natural reproduction had already begun to appear before 1893, when the plantation was under twenty years old. At present wherever there are openings in the canopy, dense thickets of young teak of all sizes up to over 20 ft. in height are to be found. Figs. 277 and 278, the former showing young plants up to 3 ft. high, and the latter older plants, give an idea of the remarkable profusion with which reproduction springs up where the cover is sufficiently light. The chief factors which have caused this reproduction,

FIG. 277. Dense natural reproduction of teak, chiefly 2 to 3 ft. high, in a teak and sissoo plantation 40 years old, Ramgarh, Gorakhpur, United Provinces: sissoo trees girdled to admit light.

FIG. 278. Dense natural reproduction of teak in a teak plantation 40 years old, Ramgarh, Gorakhpur, United Provinces.

which is unusual in plantations, are probably a soil consisting of well-aerated and well-drained sandy loam, comparative absence of heavy weed-growth, and the open nature of the plantation, which contains fairly large gaps.

Bamboos play an important part in connexion with teak reproduction, particularly in Burma, where the nature of the bamboo growth exercises a marked effect. Thus under the heavy shade of a dense growth of *Bambusa polymorpha* or *Oxytenanthera albociliata* natural reproduction is rendered impossible owing to the heavy shade, while under the lighter shade of *Dendrocalamus strictus* or *Cephalostachyum pergracile*, or where bamboo extraction or elephant grazing has reduced the canopy of the bamboos, reproduction is sometimes plentiful. The periodical flowering and dying of the bamboo, provided the forests are not fire-protected, is known from actual observations in Burma to exercise a marked stimulus on the establishment of teak reproduction. Measures for aiding the reproduction of teak in bamboo tracts are described on pp. 756 to 761.

Artificial reproduction. The question whether or not the formation of teak plantations is justifiable on silvicultural or financial grounds has on occasion been the subject of discussion. Opponents of the policy declare that plantations are silviculturally unsound, since teak is not naturally a gregarious tree, and that plantations are more exposed to insect attacks than teak in natural forest; again, plantations were curtailed in Burma some years ago on the ground that the staff and labour available were insufficient to cope with the work of thinning extensive areas of plantation. It is true that teak is not usually gregarious, though pure crops sometimes spring up on alluvial flats and on abandoned cultivation, but if pure plantations are objected to, mixtures are always possible. Plantations are no doubt more liable to insect attacks than isolated trees; yet although the Nilambur plantations are regularly defoliated, they have nevertheless proved a great financial and silvicultural success. On the other hand, it is by no means certain that the mixing of teak with other species can always be relied on to prevent insect damage; it is certainly disproved by a case recorded from North Vellore in 1917,[1] in which a group of 15 teak trees planted in the midst of mixed forest were attacked by *Pyrausta*, every leaf being skeletonized and the caterpillars being found everywhere; there were no other teak trees within miles. In Burma the so-called bee-hole borer is a more serious menace than these defoliators, and if some effective means of dealing with the pest cannot be devised it may be advisable to mix the teak with other species or to limit the size of the blocks to be planted with teak, separating them by fairly wide belts of natural forest or by plantations of other species.

Mr. C. F. C. Beeson has found that attacks of bee-hole borers are worse in pure plantations than in mixed forests rich in teak; he has also found that a dense undergrowth of bamboos, and particularly of *Bambusa polymorpha*, acts protectively, lessening the severity of the bee-hole attack. The borer can, according to Mr. Beeson, be dealt with to some extent in the conduct of thinnings. Thus (1) if trees marked in thinnings are felled before the end of the year, the borers in those trees will die; (2) the removal of dominated and suppressed trees not required in the crop removes a considerable proportion

[1] Conservator of Forests' Inspection Note, 1917.

of borers; (3) the earlier the thinnings are commenced and the shorter the intervals between them, the lower will be the incidence of the borer.

The labour question is certainly a difficulty in some localities, and plantations have to be limited accordingly, but the want of an adequate staff cannot be taken seriously as an excuse for not forming plantations, since the remedy is obvious. It has been held that plantation teak is inferior in quality to natural teak, but Mr. Pearson has carried out two separate series of tests with plantation teak from Burma, in both of which it was found that the timber was in point of strength in no way inferior to natural teak.

Wherever conditions are suitable, on the other hand, there are strong arguments in favour of teak plantations. It is obvious that land which is made to yield, say, 40 mature teak trees per acre after about 100 years or less is being utilized to much greater advantage than the same land which under natural conditions yields only a few mature trees per acre in 150 years or more. Again, the cost of tending, upkeep, and supervision for a given number of trees is much reduced by the concentration of work possible in the case of plantations, and this results in more rapid growth and a considerable reduction of the rotation, which means a great financial gain. Experience in Burma has shown that *taungya* plantations formed on correct lines cannot be approached for cheapness as a means of increasing the stock of teak, and that the financial prospects of such plantations are decidedly good. Finally the financial results of the Nilambur plantations, quoted below, should remove any doubts as to the desirability of forming teak plantations, always provided care is taken regarding important details such as the choice of site, the extent of area planted, the method of formation, a suitable mixture of species or isolation of planted blocks where the attacks of insects, and particularly the bee-hole borer, are to be feared, careful tending throughout the life of the plantation, and other matters.

Particulars of some teak plantations. Teak plantations have been formed to a greater or less extent in many parts of the natural region of this tree as well as in localities outside its natural habitat. A short account of some of these plantations may be of interest.

Central Provinces. Small plantations exist in various districts. In the Sipna valley of the Melghat forest division of Berar about 1,000 acres were planted between 1868 and 1879.

Bombay. A good deal of planting has been done from time to time in different localities. The earliest plantations formed were those at Sulgeri, Kadra, and Mardi in the Kalinaddi valley in North Kanara. The Sulgeri plantation was started in 1867–8, and continued until 1881–2, by which time the area amounted to 410 acres. The Kadra plantation was commenced about 1865 or 1866, and continued until 1881–2, when the area aggregated about 200 acres. The Mardi plantation was commenced in 1869–70, and an area amounting to 102 acres was planted at different times. The spacing was 9 ft. by 9 ft. The success of these plantations has been variable. Most of the planted area is on laterite, with very shallow soil in places, and here the growth is poor or complete failure has resulted. The plantations also appear to have suffered from want of tending in the earlier years, and from the fact that thinnings were too long delayed. Considering that much of the area has

proved a failure, the cost has been extravagantly high; the expenditure on the Kadra and Mardi plantations up to 1908–9 is reported to have been as much as Rs. 150 per acre, while the receipts amounted to Rs. 16 per acre.

Madras. Teak plantations have been formed from time to time in various parts of Madras, but by far the most important plantations are those in the Nilambur valley in South Malabar. The Nilambur plantations owe their inception to the foresight of Mr. Conolly, Collector of Malabar, who in 1840 foresaw the shortage of teak likely to occur through the depletion of the natural forests, and urged the formation of teak plantations in the Nilambur valley, a proposal which was approved by Government. After three years of experimental work, regular clear-felling of the existing forest and planting with teak was started in 1844; this work has been continued more or less steadily ever since, though no planting was done from 1877 to 1885. The total area planted up to 1918 was approximately 6,500 acres.

The Nilambur valley is an ideal situation for teak plantations. The plantations are situated at an average height of about 100 ft. above sea-level. The valley is surrounded on three sides by hills, of which the highest, the Nilgiris, rise to 8,000 ft. The village of Nilambur itself is about 45 miles by road from the coast. The normal rainfall at Nilambur is 109 in., and the shade temperature varies from 80° to 90° F. throughout the year. Over much of the area the soil is a deep fertile well-drained alluvium admirably suited for teak; this is interrupted at intervals by patches of laterite, often in the form of low hills or undulations. Between the best alluvial soils and the laterite, various gradations of soil occur. The laterite produces teak of poor quality, and in many places the teak has failed altogether; hence it has been decided, as a result of the experience gained, to avoid planting on laterite areas of poor quality during the second rotation. The Nilambur valley is drained by a good floating-stream which flows into the sea at Beypore, immediately to the south of Calicut, and the outturn of the plantations can be delivered at the coast at the low cost of 2a. 6p. per cubic foot, inclusive of all charges. Much of the timber finds its way in small trading vessels to Persia and Arabia, where poles as well as larger timber are much in demand. Planting has been carried out in large contiguous blocks, and hence the Nilambur plantations have not had to contend, so far as cost of upkeep goes, with the adverse conditions from which so many of the Burma plantations have suffered by being scattered in small isolated patches amidst natural forest.

The Nilambur plantations have proved a conspicuous financial success. In 1912 the financial results to date were worked out, and it was ascertained that after allowing 4 per cent. compound interest on all receipts and charges the total revenue, expenditure, and surplus amounted respectively to Rs. 56,22,090, Rs. 54,79,531, and Rs. 1,42,559; the total planted area was then roughly 6,000 acres. The rotation has recently been fixed at seventy years, and the final fellings of the first rotation have already begun. The net surplus for the year 1917–18 was Rs. 2,75,532 for the 6,500 acres planted, or Rs. 42·4 per acre per annum; the future surplus is estimated to be over Rs. 30, and may possibly reach Rs. 40 per acre per annum. The results would have been even better but for the fact that the planted area contains a certain proportion of laterite outcrops and badly-drained ground where teak has failed.

Average figures of outturn for the Nilambur plantations will be found below in the yield table (p. 763) given under 'statistical'. In 1917 the largest teak tree in the plantations had a girth of 9 ft. 8 in. and a height of 135 ft.; it was situated in one of the earliest plantations, in the Iruvallikava block.

Figs. 279 to 283 show typical examples of plantations of various ages at Nilambur.

Coorg. The oldest teak plantation in Coorg is the Karmad plantation, started in 1868 and extended gradually till 1875. Its total area is 197 acres, of which in 1918 about 120 acres were estimated to be fairly well stocked with teak. The formation of this plantation does not appear to have been carried out on correct lines, in that the existing forest growth was incompletely felled, and the plantation suffered for many years from the presence of overhead trees; cleanings and thinnings were also neglected to some extent. The total expenditure on the plantation from 1868 to 1918 amounted to Rs. 26,948, or Rs. 136 per acre. *Kumri* (*taungya*) plantations were started in 1891, and have been continued subsequently; many of these are very thriving, though some have suffered for want of tending. These plantations have been raised from nursery transplants, but latterly direct sowings under the Burma method have been tried with good results.

Travancore. Bourdillon states that teak plantations were commenced in Travancore in 1866–7, and have been gradually extended since then, the aggregate area in 1908 being 2,666 acres. He mentions that the final fellings are expected to be made in the ninetieth year; also that it has been calculated that after charging 4 per cent. interest the sale of thinnings will pay off all expenditure by the seventieth year, and that at the time of the final felling in the ninetieth year there will be a balance to the good of Rs. 6,887 per acre, representing an annual profit of Rs. 76·6 per acre from the commencement.

Burma. Teak plantations were commenced in Burma in the fifties of last century, one of the oldest being the Thinganninaung plantation on the upper Winyeo river (Ataran) in Tenasserim, which was started about 1856. Several of the older plantations are associated with the name of Dr. Brandis. Among these may be mentioned the Myodwin plantation situated on flat alluvial ground about ten miles east of Zigôn in the Tharrawaddy district. It was extended subsequently in 1885–6, and again about 1904. The old plantations were formed by clearing and burning the existing jungle and digging up the ground; in 1862 seed was sown in lines 6 ft. apart, in 1863 nursery transplants were put out 3 ft. by 10 ft., and in 1864 seed was sown 3 ft. by 10 ft. The plantation of 1904 was formed under the *taungya* system, seed being sown with a spacing of 6 ft. by 6 ft. Another plantation formed by Dr. Brandis is that of Kangyi, about six miles east of Zigôn; this plantation, which is also situated on alluvial ground, was formed in 1864–5, and has produced a girth increment of at least 1 inch per annum. Another old plantation is that at Kywemakaing in the Kadinbilin reserve, Tharrawaddy. It was commenced in 1867, when an area of 58 acres was planted, and in 1869 it was increased by 86 acres, making a total of 144 acres. The spacing was chiefly 6 ft. by 6 ft., with a small area 10 ft. by 4 ft. This plantation is on hilly ground, and although the success varies it is good on the whole. It has proved expensive, since the original forest was felled and burnt departmentally without any

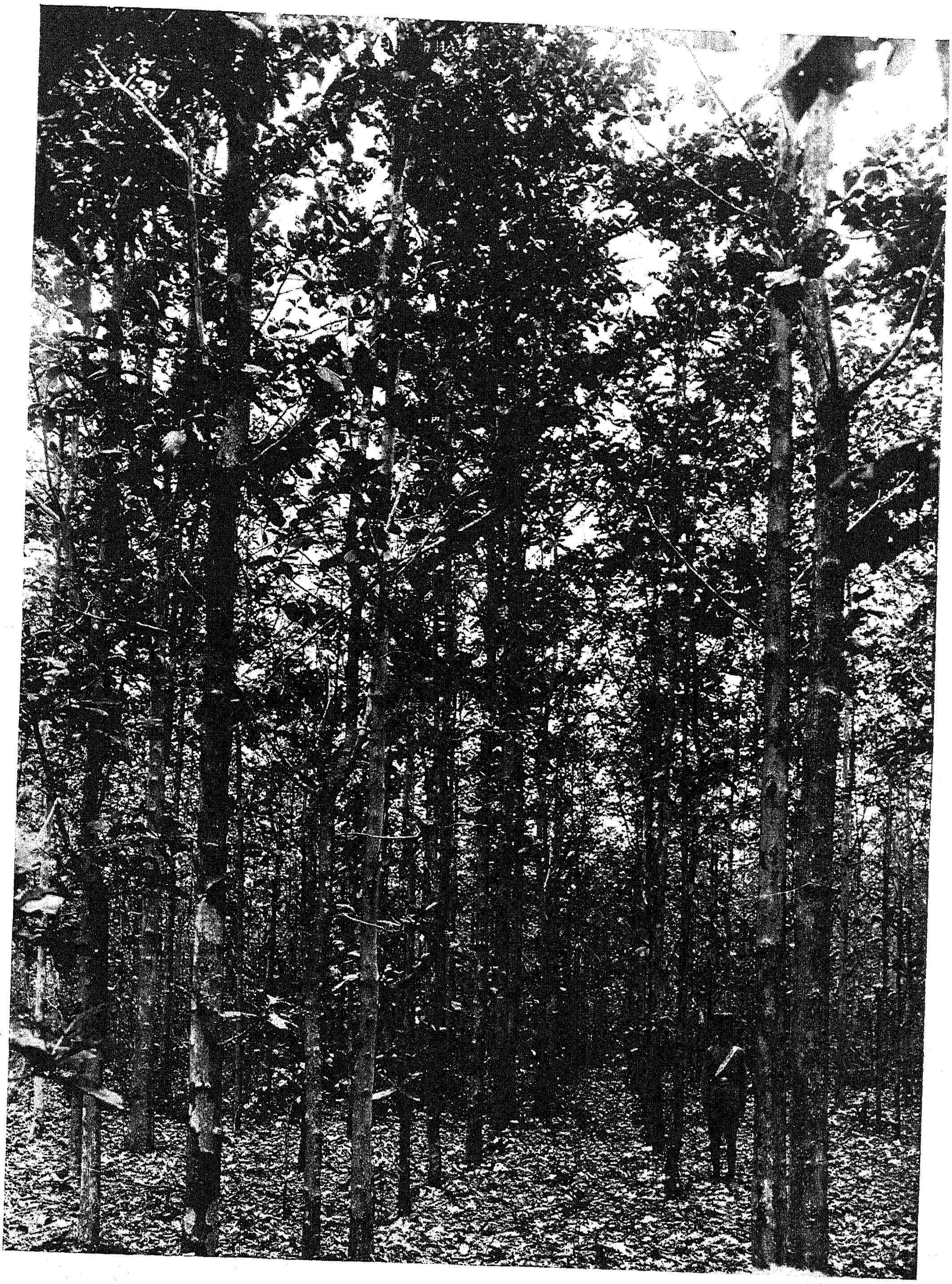

FIG. 279. Teak plantation 14 years old, Ramalur block, Nilambur, South Malabar.

Fig. 280. Teak plantation 20 years old, Edacode block, Nilambur, South Malabar.

cultivation of field crops. The cost amounted to Rs. 112 per acre up to 1884, and Rs. 120 per acre up to 1904.

The earlier Burma plantations were formed without the aid of field crops, and have accordingly been designated 'regular plantations'. The idea of combining the raising of teak with the practice of shifting cultivation (*taungya*), so prevalent among the jungle people of Burma, originated with Dr. Brandis, though the credit of applying it in its practical details in the Tharrawaddy forests appears to belong to Colonel W. J. Seaton, who was in charge of those forests from about 1863 to 1870. *Taungya* plantations were commenced in Tharrawaddy on a small scale in 1869, and since 1873 have been extended almost continuously. These plantations have proved a cheap and efficient means of raising teak plantations on a large scale, and are admirably adapted to the habits of the jungle population. They have been formed extensively in many parts of Burma. In 1917 the total area of teak plantations, including 6,021 acres of teak mixed with cutch (*Acacia Catechu*), was 71,731 acres, of which no less than 68,364 acres consisted of *taungya* plantations.

Details regarding the method of formation and tending of *taungya* plantations, with figures of cost, are given below. The mistake of scattering these plantations in small isolated blocks is referred to on p. 735; but for this mistake the potential value of the teak plantations of Burma as profit-earning concerns would be much higher than it is. There is nevertheless a great future before the *taungya* system in Burma, provided definite concentrated blocks of forest are set aside for planting up under regular schemes; in particular the conversion of blocks of evergreen or semi-evergreen forest into profitable teak plantations holds out considerable promise. The labour difficulty might be got over where possible by the establishment of forest villages; the necessary increase of staff for purposes of supervision could well be justified on financial grounds wherever the choice of site has been carefully made. Perhaps the only serious obstacle to the extension of teak plantations, as far as labour conditions will permit, is the risk of encouraging the spread of the bee-hole borer. This danger is sufficiently real to form a valid reason for avoiding pure plantations of teak over large areas and for finding suitable species for growing in mixture with the teak.

United Provinces. The plantation at Ramgarh in the Gorakhpur district, which has regenerated itself in a remarkable manner, has already been referred to. Recently teak has been tried in connexion with afforestation work in ravine lands in the Etawah district, and has shown rapid growth in the earlier years. Teak trees are planted, and grow moderately well if they escape frost, as far north as Dehra Dun. There is a small plantation at Lachiwala in the Dun, but it has been cut back repeatedly by frost, and may be regarded as a complete failure.

Bihar and Orissa. Within recent years teak plantations have been formed in the Puri district.

Bengal. There is a plantation at Bamunpokri in the Darjeeling *tarai*, and a small one, dating from 1869, in the Lower Tondu forest near Gorumara in the Jalpaiguri district; both of these have succeeded fairly well. The latter was at one time reported to be a failure, but when I visited it in 1915 I found it looking healthy, although it appeared to have suffered from want

of early tending. It is situated on well-drained sandy loam along a high bank ; the rainfall here is about 160 in., and frost is unknown. At the time of my visit it was 46 years old, and the trees were found to have an average and maximum girth of 3 ft. 9 in. and 5 ft. 4 in. respectively, omitting suppressed stems, which is a fair rate of growth. The Sitapahar plantations along the Karnafuli river in the Chittagong hill tracts were commenced in 1872 and continued in subsequent years, but a severe cyclone in October 1897 devastated the plantations and destroyed a large proportion of the trees ; within recent years further plantations have been formed under the *taungya* system in this locality, and plantation work is being continued on a fairly large scale.

Assam. The Kulsi teak plantations in the Kamrup district, formed in 1872 and following years, have done well ; there is also a plantation at Makum near Dibrugarh.

Andamans. Teak plantations in the Andamans were started in 1883 and continued spasmodically. From 1883 to 1889 teak and padauk (*Pterocarpus dalbergioides*) were raised in mixture, but the former outgrew and suppressed the latter. The teak has done well both on padauk soil and on evergreen soil, but rather better on the former than on the latter. The cultivation of teak promises to be highly successful, and to be more remunerative than that of the indigenous padauk ; the growth is nearly, if not quite, up to the average for Burma. The earlier plantations were formed by transplanting from the nursery, and the later ones by direct sowing.

Arakan. There is a small plantation dating from 1825 on the Thade stream behind Sandoway. In 1915 there were 106 trees in it, of which seven were over 7 ft. in girth, the largest being 12 ft. 3 in. in girth. A plantation formed about the same time in the plains near Taunggôk in the Sandoway district is reported to have been a failure. There is a plantation in the Uthalin valley dating from about 1870. In the Akyab subdivision there are numbers of small plantations formed between 1872 and 1875. In 1918 the number of plantations dating from before 1900 was about 100, aggregating 195 acres, the largest being 32 acres, while many of them were less than 1 acre in area. From 1900 onwards plantations have been extended considerably, and on suitable well-drained sites the growth is good.

Choice of site. The importance of careful selection of sites for teak plantations has not always been fully realized. Perhaps the most essential factor is good drainage, since badly drained ground, or ground liable to inundation for many days at a time, is totally unsuitable for the growth of teak. Laterite should be avoided if the rock is anywhere near the surface ; this is well illustrated at Nilambur, where the plantations formed on low laterite hills have not produced anything but small-sized trees, and in many cases have proved an entire failure. Similarly poor shallow soil should be avoided, since although teak can persist on such ground the trees remain stunted, and plantations formed in such localities cannot be expected to prove financially successful.

Teak can be grown successfully on ground which is not naturally teak-producing, even within its habitat. Some of the most promising teak plantations in Burma have been formed on ground which previously supported evergreen forest. The soil of tropical evergreen forest being particularly fertile, the growth of the teak on such ground is often very good ; the growth

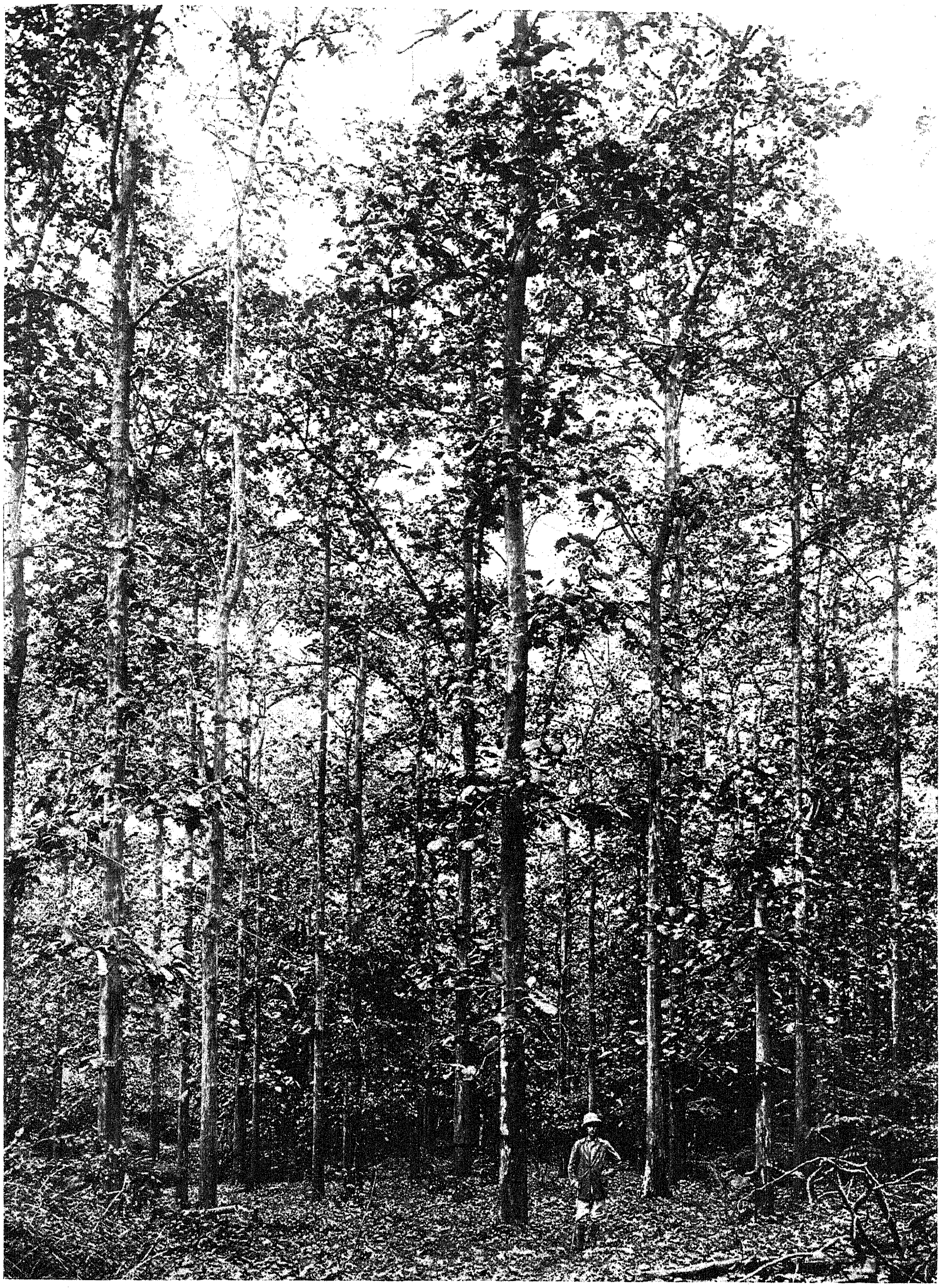

FIG. 281. Teak plantation 54 years old, Elanjeri block, Nilambur, South Malabar.

Fig. 282. Teak plantation 57 years old, Panengode block, Nilambur, South Malabar.

of weeds and climbers is likewise luxuriant, and hence weedings and cleanings in plantations on ground formerly occupied by evergreen forest are a specially heavy item. Plantations can be formed with great success on well-drained alluvial ground, as witness some of the plantations of Burma and Nilambur; early prognostications notwithstanding, the trees on such ground have satisfactorily maintained their soundness throughout their life, and are in some cases approaching maturity. On alluvial ground, however, great care is necessary to carry out repeated climber-cutting operations, as climbers often grow in great profusion in such places. Savannah lands are, as a rule, unsuitable for the formation of teak plantations.

The size of a teak plantation is, from a financial point of view, a matter of great importance. In Burma, with its wealth of plantations, a cardinal mistake has been made in scattering these in numerous isolated patches, some only one or two acres and others several acres in extent, in the midst of natural forest. Many of these have been lost sight of, and have perished owing to the rapid encroachment of the surrounding bamboos and jungle. Those which survive have been saved only at the cost of periodical cleaning of their boundaries at frequent intervals, the surrounding jungle being thus kept at bay. In the case of small scattered plantations the cost of such work soon outweighs any possible return to be derived ultimately from the plantation; on this account many of the Burma plantations must be written down as a financial loss, while many of the smaller plantations have disappeared entirely, their site being marked only by the remains of the boundary-boards, which serve the purpose of tombstones. In a moist climate like that of Burma, where any clearing is quickly invaded on all sides by the luxuriant surrounding forest growth, and where the boundaries of plantations have to be repeatedly cleared, it is well to fix a minimum area to plant up in the course of one or more years in one self-contained block. Only by this means will the boundary be short enough, in comparison to the area of the plantation, to bear the cost of periodical clearing. In Burma this minimum area was fixed some years ago at 25 acres. In this respect the Nilambur plantations have been formed on sounder lines than the majority of the Burma plantations, as they are for the most part comprised in blocks of considerable extent. This defect in the Burma plantations has been due largely to an exaggerated notion that no forest should be cleared for the formation of plantations which contains any teak trees. This argument, however, can hardly hold in view of the fact that in place of a few scattered teak trees the ground will be made to support perhaps forty trees of valuable species to the acre at maturity, allowing for a suitable mixture of other trees besides teak where the bee-hole borer is to be feared. The sparing of a few isolated teak trees can certainly never justify the financial loss involved in scattering the plantations in small isolated blocks. In dry climates such as those met with in many of the teak-bearing tracts of the Indian Peninsula, this rule regarding the size of plantations would not hold to the same extent, if at all, except in so far as concentration for purposes of tending and upkeep is concerned.

Spacing. The spacing now almost universally adopted in Burma is 6 ft. by 6 ft., this giving even growth all round and being close enough to produce a complete canopy in a few years. In the earlier plantations in Burma spacings

of 12 ft. by 3 ft. and 9 ft. by 4 ft. were common; the plants are thus fairly close together along definite lines, and weeding is facilitated, but the canopy takes longer to close up than in 6 ft. by 6 ft. spacing. In the Tharrawaddy plantations of 1876 and 1877 belts of teak consisting of three lines 6 ft. apart, each belt separated by an unplanted strip 30 ft. wide, were tried; in 1878 wider belts were formed, eight lines 6 ft. apart being planted, and unplanted strips 30 ft. wide being left between the belts. This system was apparently found unsatisfactory, as it was discontinued.

In the Nilambur plantations a spacing of $6\frac{1}{2}$ ft. by $6\frac{1}{2}$ ft. has been the general rule; a spacing of 6 ft. by 6 ft. was adopted for a time prior to 1904, but it was afterwards decided to plant with a spacing of 8 ft. by 8 ft. on first-class soils and 6 ft. by 6 ft. on second-class soils. Wide spacing, however, has now been given up, and the rule in recent years has been to plant $6\frac{1}{2}$ ft. by $6\frac{1}{2}$ ft. on soils of good quality, and 6 ft. by 6 ft. on soils of poorer quality. Although wide spacing is more economical than close planting, reckoning the cost of planting an acre at a given rate per plant, at Nilambur it is said to have resulted in a fair proportion of the trees being forked at a height of 20 to 25 ft. from the ground. Mr. P. M. Lushington, again, notes that the extra cost of close planting at Nilambur is recovered from the first thinnings, and that close spacing has a great advantage in producing straight clean stems. Another result of wide spacing is that weedings have to be continued longer, and give more trouble, than in the case of close planting, so that expenditure saved in the cost of formation has to be added to the cost of tending. This was found to be the case in Coorg, where a spacing of 10 ft. by 10 ft. was tried at one time, but was discarded owing to the trouble given by weeds. In Travancore a spacing of 15 ft. by 15 ft. was tried during the first few years of plantation work, but this was afterwards discarded for a spacing of 5 ft. by 5 ft. or 6 ft. by 6 ft.

Preparation of seed. In most parts of India it is customary to subject teak seed to some form of preliminary preparation in order to hasten germination, without which the seed is found to lie dormant for a year. Provided the seed is sown well before the early showers preceding the monsoon, such preparation is not always necessary; it is not ordinarily resorted to in Burma, and the results are all that can be desired. In India many different plans are adopted. At Nilambur soaking for 48 hours before sowing in the nursery is found to give good results; the soaking is effected by placing sacks of seed in running streams. Exposing the seed to the weather for a whole year in the open has been found successful in Bombay. In Kanara seed sown in beds early in April, and watered daily until the rainy season, has been found to germinate fairly well, though some of the seeds lie dormant for a year. Mr. L. S. Osmaston[1] has described a method which has given uniformly excellent results in Satara, where the rainfall is about 24 in. A hole large enough to hold all the seed is dug in April in a sunny spot, filled with seeds, covered with a layer of earth 1 in. thick, and thoroughly drenched with water every third day for six weeks. The seed is then taken out and spread in the sun for three weeks, by which time the rainy season is about to commence, when the seed is sown and germination takes place readily. Another plan, successfully tried in Surat, is to

[1] Ind. Forester, xxxiv (1908), p. 534.

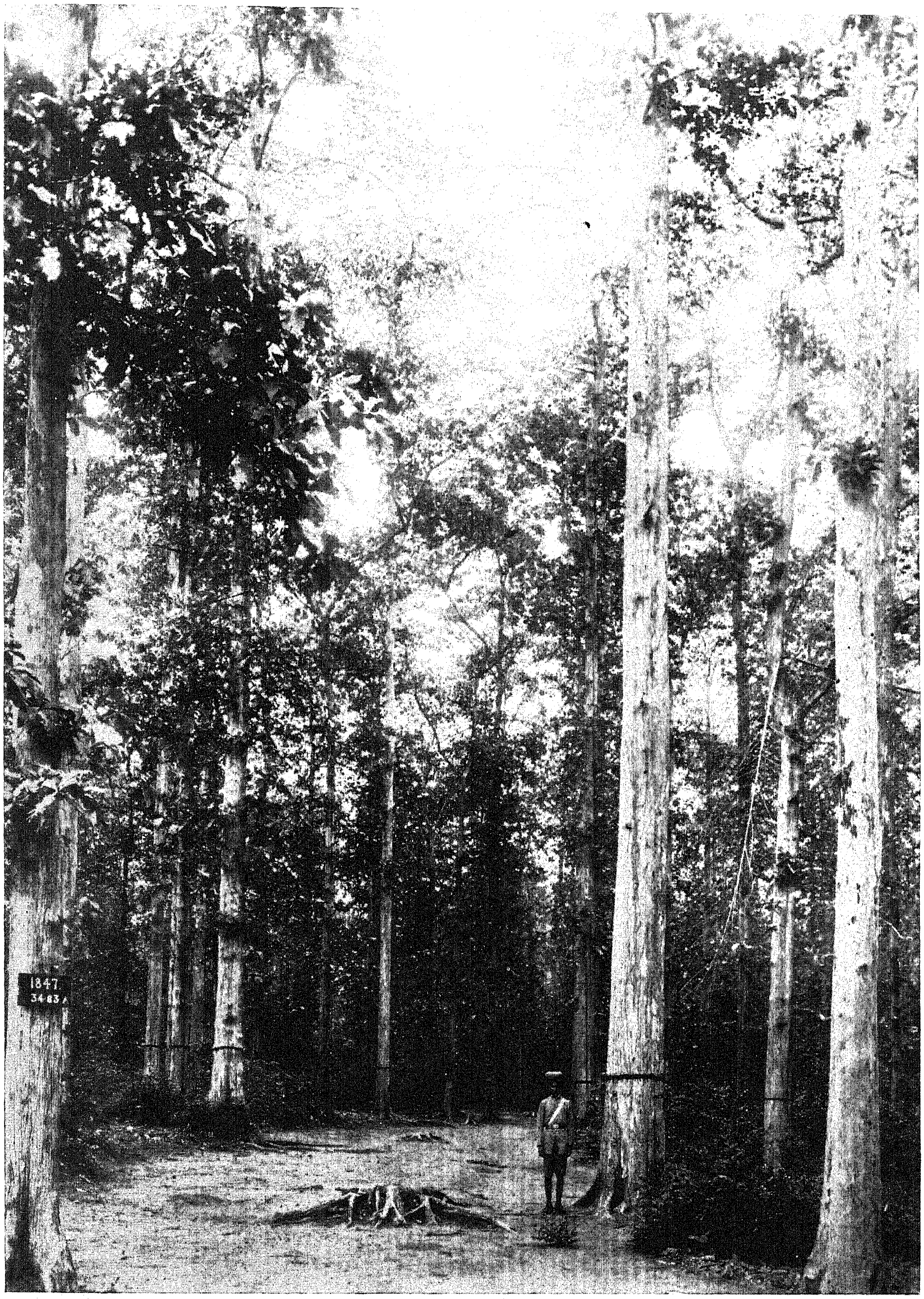

Fig. 283. Teak plantation 65 years old, Moolathamanoo block, Nilambur, South Malabar: tree with man at base 7 ft. 8 in. in girth.

FIG. 284. Young teak *taungya* plantation in second year, Burma.

subject the seed to alternate soaking in water for twenty-four hours and drying on the ground for four days, repeating this process for a fortnight; the seed is then placed in a hole in the ground and kept moist until germination begins, when the germinating seeds are removed daily and sown. Slight charring has been found to stimulate germination, but this method is not to be recommended, since the vitality of the seed is destroyed if the heat is too intense. Mr. E. M. Hodgson[1] in Surat found that soaking for twenty-four hours in lukewarm water prior to sowing invariably induced germination in twelve to twenty-four hours. A method which is said to give good results in Bombay is to fill a pit with alternate layers of seeds and earth 1 in. thick, cover it with earth, and keep it well drenched with water for about a fortnight; the seeds and earth are then mixed well together and watered until germination begins. A method tried with success in Ceylon is to spread the seed in a layer 4 in. thick on a mat in the sun and keep it constantly watered; germination starts in about three days, and the germinating seeds are removed daily and sown in the nursery. This method should be carried out only in fine weather, since the seeds are apt to rot if kept too moist without being exposed to the sun. In an experiment carried out by Mr. H. Tireman in Coorg in 1916 good results were obtained by placing the seeds between gunny-bags in April and watering them well; germination commenced in 13 days, and ceased 26 days later.

Covering of seed. The depth to which seed, whether sown in the nursery or direct in the forest, should be covered with earth is a matter of some importance. A number of experiments which I carried out at Dehra Dun, in which seed was covered to various depths up to 2 in., showed that the best results are obtained by covering it to a depth of less than ½ in. These experiments were repeated several times, and the result obtained in each case was the same.

Nursery treatment and transplanting. Teak may be raised either by direct sowing or by the transplanting of seedlings which are raised as a rule in the nursery; the former method is the more usual in Burma and the latter in India, though direct sowings appear to have come more into vogue in India within recent years. The methods of raising teak seedlings in the nursery vary in detail. Seedlings may be transplanted the year of sowing or may be kept in the nursery for a year. In the former case any injury to the root should be avoided, and small-sized seedlings should therefore be used, but in the latter case the plants will stand pruning of the taproot, provided the stem is also pruned down.

The method which has been employed for raising most of the plantations in the Nilambur valley is as follows:

Seed-beds are formed near the area to be planted; good free soil is selected, dug to a depth of 3 ft. and broken into fine mould, after the removal of weeds, roots, and stones. An edging 3–4 in. high is constructed round the beds, which have a width of about 2½ ft. between edgings. The seed is collected in February from vigorous trees and sown about the 7th to 15th April; before being sown it is soaked for 48 hours in water. About 240 lb. of seed, sown broadcast, suffice for 150 ft. length of bed. The seeds are covered with earth to a depth of ½–¾ in., and the beds are then covered with straw, a few leafless

[1] Ind. Forester. xxvi (1900), p. 279.

twigs being placed below the straw to prevent it from mixing with the earth ; the object of the straw is to prevent the earth from being washed off the beds when watering is in progress. The beds are watered copiously every day, and germination takes place in 10–20 days, when the straw and twigs are removed. Thereafter watering is carried out more sparingly as the plants become stronger. The monsoon sets in, as a rule, in the beginning of June, and it is of the greatest importance that the seedlings should be of the correct size, that is, about 3 in. high, with two pairs of leaves besides the cotyledons ; the third pair of leaves are usually a good deal larger, and if they have appeared they should be nipped off. The larger plants are discarded in favour of those about 3 in. high. Planting should always be carried out during continuous rain ; if this is not done, or if there is a break of a few days after planting, much failure results. Planting should be completed as early in the rainy season as possible ; in this case the seedlings reach a height of several feet by the end of the season, while those put out late show poor development. If late planting is unavoidable, small seedlings which have germinated late are selected in preference to larger ones with long thick taproots. The planting site is felled in December, the felled material being allowed to dry until March, when it is burnt, the unburnt logs being then cross-cut, piled, and again burnt. Lining is then carried out, and after the ground is softened by rain pits 10–12 in. cube are dug and filled in with the loose earth, in which the planting hole is made with the hand or with a bamboo stick at the time the seedling is planted ; the earth is then replaced round the roots and pressed well down, care being taken not to place the seedling in a hollow, but rather to raise it slightly above the surrounding level of the ground, in order to allow for the settling of the earth.

Under this system the cost of formation is somewhat high. Mr. J. Ferguson, who was in charge of the Nilambur plantations for many years, made out the following statement of the average cost per acre of clearing and planting on forest land :

	Rs.	a.	p.
Weeding undergrowth preparatory to felling	2	0	0
Felling	5	0	0
Firing after felling	0	4	0
Cross-cutting remains of first burning	3	8	0
Piling and burning off clear	10	0	0
Lining, marking, pitting, and planting out	3	8	0
Weeding and hoeing round the plants	2	8	0
Second, third, and fourth weedings at Rs. 1–4–0 each	3	12	0
Collection of teak seed	0	8	0
Preparing, sowing, and watering nursery beds	3	0	0
Contingencies	2	0	0
Total	36	0	0

This does not include the cost of superintendence. The average cost of formation is now usually reckoned at Rs. 40 per acre for complete establishment up to the first thinning. Pruning is carried out only in the case of unlignified branches of young plants up to three years of age ; these often develop forked stems or produce strong side branches which may be pruned off with advantage.

In some localities, particularly in parts of Bombay, it is customary to

keep the seedlings for a year in the nursery before planting them out. The seedlings are usually pricked out 6 in. apart in the nursery about June or July of the first year, when 2 or 3 in. high, weeded regularly and watered in dry weather, at first frequently and later as sparingly as possible. They are planted out early in the following rainy season, when about a year old, the stem being, as a rule, pruned down to about 2 to 3 in. from ground-level and the root being trimmed.

A plan which has been adopted in some places is to sow the seed in the nursery beds about the beginning of the rainy season and to do no watering until about February or March the following year; this induces germination within a short time, and the plants reach a height of about 9 to 12 in. by the beginning of the rains, when they are planted out.

Transplanting natural seedlings. The transplanting of natural forest seedlings, to supplement dibblings, has been carried out with success in the Katha district of Upper Burma. A remarkably successful experiment was carried out several years ago in the Tharrawaddy forests by Ranger Maung San Lon. He cleared and burned a small patch, and in it planted the thickened root-stocks of young natural teak plants which had been killed back repeatedly by fire or suppression; the stems were pruned down, the roots were trimmed, and the thickened root-stocks were planted somewhat after the manner of potatoes. The result was a flourishing plantation of vigorous plants.

Ranger J. D. Rego [1] has described the success attending the transplanting of natural teak seedlings in the Mundgod pole forests of North Kanara, particularly in patches where the refuse of fellings had been burnt. It was found that natural seedlings dug up and transplanted showed better growth, probably owing to the loosening of the soil, than natural seedlings left *in situ* and tended by mulching in the manner already described on p. 723. For this purpose small seedlings 2 to 3 in. high are found to be best; these are found in large numbers at the beginning of the rains on fire-lines and roadsides, and the supply is augmented by creating small nurseries in the coupes by burning leaves and brushwood and sowing seeds on the burnt patches. The best results of all are attained by transplanting seedlings into burnt patches, in which case they attain a height of 1–2 ft. in the first year, and no weeding is necessary. Seedlings planted on unburnt ground require weeding for two and sometimes for three years. The method of burning adopted is to collect all the brushwood and felling refuse into heaps, which are burnt during the hot weather immediately after a shower of rain, when there is little fear of the fire spreading.

The Burma taungya system. This is the system which has been almost universally employed in Burma for many years past, and has proved a most efficient and economical method of forming teak plantations. It consists in dibbling teak seed along with field crops in temporary forest clearings and tending the crop of teak after the field crops have been reaped. One of the most important operations connected with this system—and the same applies to any system of clearing forest land for plantation purposes—is to secure as complete and thorough a burning of the felled material as possible before sowing the crops and the teak. This is well understood by the *taungya*-cutters,

[1] Ind. Forester, xliii (1917), p. 197.

and it means all the difference between success and failure. If the burning is not thorough, half-burnt logs and stumps encumber the ground, preventing regular planting and hindering subsequent weeding. Thorough burning consumes all the felled trees and many of the stumps, as well as the seeds of weeds and climbers, prevents regrowth from felled trees and bamboos, and enriches the soil with the ashes. In order to ensure thorough burning the forest growth should be felled early in the cold season, and the felled material should be carefully protected from fire through the cold and hot seasons. It should then be burnt late in the hot season, by which time it will have become reasonably dry, but care should be taken not to delay the burning until the early showers preceding the monsoon, otherwise complete burning may be impossible. In this way a fierce conflagration results, and the felled material is thoroughly burnt ; any material which is not consumed is collected into heaps and burnt again.

As soon as the burning is finished the lining out is done, bamboo stakes being inserted in the ground at the required distances. The teak seed is then sown, three seeds as a rule being sown at each stake and very lightly covered ; the sowing should be completed before the monsoon breaks. At the same time a small nursery is made at a convenient place in the clearing from which seedlings are obtained to fill up gaps where failures occur. The field crops, which are sown about the same time, vary ; hill rice is the commonest crop, but in some localities maize, sesamum, or other crops are grown. The lines of young teak require to be kept free from suppression by the crops and by weeds ; the cultivator attends to this. About December or the beginning of January, after the field crop is reaped, the lines of teak are cleared by the cultivator—or *ya*-cutter, to give him his usual name—and all bamboo stakes which have been lost are replaced by fresh ones. An enumeration is then made of all the living plants and all the blanks or dead plants ; this enumeration is carried out under close supervision by men provided with split bamboo tallies on which each plant is nicked off in turn. Payment is made to the *ya*-cutter usually at the rate of one rupee for every hundred living plants found at this enumeration. With a spacing of 6 ft. by 6 ft. the number of plants per acre is approximately 1,210, and the cost of formation for a completely stocked plantation, including weeding during the first season, amounts to about Rs. 12 per acre. In localities where there is much demand for *taungya* land the initial cost can be reduced or even eliminated altogether. In the northern parts of Upper Burma *taungya*-cutters are paid nothing ; they do all the clearing, burning, and weeding during the first year without payment.

The system of forming *taungya* plantations varies in detail, but that just described is commonly in vogue in the forests of the Pegu Yoma. In some localities the area is cultivated for two years in succession, teak seed being sown the second year. The weeding and cleaning of *taungya* plantations is a matter of great importance, and is referred to below under ' tending '.

The cost of *taungya* plantations has varied considerably in the past, but it should be comparatively small if the work is properly carried out and supervised.

In the case of the Tharrawaddy plantations the average cost, as worked out a few years ago, is as follows :

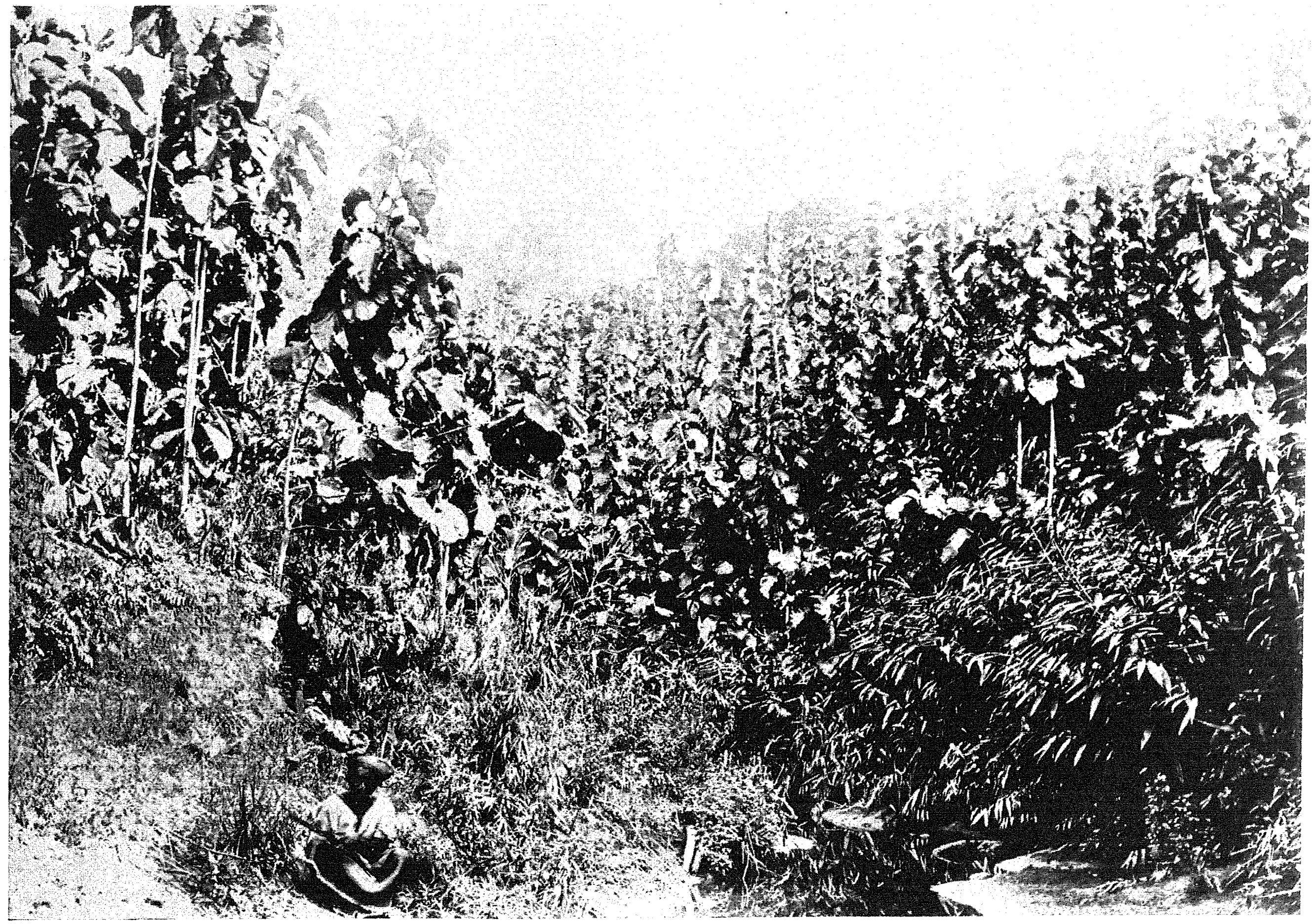

FIG. 285. Young teak *taungya* plantation in third year, Tharrawaddy, Burma.

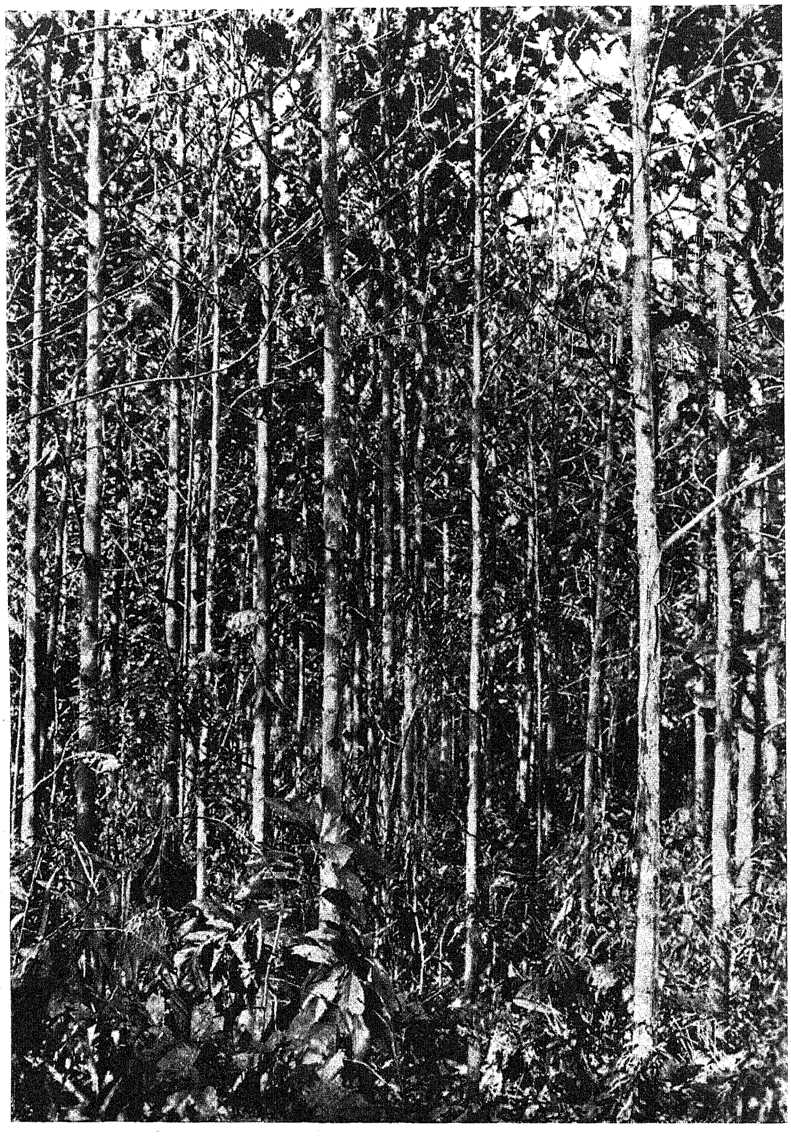

Fig. 286. Teak *taungya* plantation 9 years old, ready for first thinning, Tharrawaddy, Burma.

Tectona grandis: average cost of *taungya* plantations, Tharrawaddy.

Age. Years.	Operations.	Cost per acre. Rs.	a.	
1	Formation	10	0	
2	Weeding	2	0	
3	,, ...	2	0	
4	,, ...	1	8	
				Rs. 15–8
7	Cleaning	2	0	
10	Cleaning and thinning . .	2	8	
				Rs. 20
15	Cleaning	2	0	
20	Thinning	2	0	
				Rs. 24
25	Cleaning	2	0	
30	Thinning	2	0	
				Rs. 28
40	Thinning	3	0	
				Rs. 31

In the more accessible plantations of Tharrawaddy the produce of thinnings begins to be saleable at an age of 20 years, and it is reckoned that the whole cost of the plantation, with compound interest to date, is recovered in 40 to 50 years; this, however, is not the case in all the plantations either of Tharrawaddy or of other localities. Generally speaking it may be said that it ought to be possible to establish *taungya* plantations and bring them through the weeding stages up to say the fifth year, at a cost of not more than Rs. 20 per acre.

Fig. 284 gives a general view of a young teak *taungya* plantation; Fig. 285 shows a well-stocked young plantation; and Fig. 286 shows a plantation nine years old, ready for the first thinning.

Kumri plantations in Coorg. The *taungya*, locally known as *kumri*, method of forming teak plantations has been practised for some time in Coorg, the work being done mainly by the Kurumbars. Teak seedlings are supplied by the Forest Department, and these are planted out by the Kurumbars free of cost with their crops, which consist usually of hill rice and *ragi* (*Eleusine coracana*). The area is again burnt and cultivated a second year, casualties among the teak being replaced; the burning is found to stimulate the growth of the teak. The Kurumbars tend the plants until they are 2½ years old, and then receive payment at the rate of Rs. 1–4–0 per hundred surviving plants; this includes payment for the collection of teak seed.

Recently direct sowing after the Burma plan, instead of transplanting, has been tried in the *kumris* of Coorg, and the results have proved successful provided sowing is done as soon as possible after the clearings are burnt, in order to obtain the benefit of the early showers in April and May. Weedings are carried out for the first two or three years.

Line sowings with field crops. Mr. L. S. Osmaston[1] has described the results of experimental line sowings of teak and other tree species along with field crops in the dry parts of the Bombay Deccan, where the normal rainfall is about 20 in. He states that in his experience the only successful method of restocking these dry tracts is by means of agriculture combined with forestry;

[1] Ind. Forester, xxxiii (1907), p. 265.

the success in any year, however, depends largely on the rainfall. It was found better to entrust the work to lessees than to carry it out departmentally. Two different methods were tried, in both of which a two-years lease was given; the field crops employed were sesamum, cotton, and lesser hemp. Under the first method the lessee cultivated field crops during the first year, and sowed tree seeds along with the crops during the second year, carrying out two weedings during the rainy season; one line of tree seeds was sown alternately with three lines of field crops, and, the lines being about 1 ft. apart, the lines of tree species were about 4 ft. apart. Under the second method the tree seeds were sown in the first year of the lease in broad strips of four lines each 1 ft. apart, alternating with strips of field crops 8 ft. broad; the lessee cultivated field crops between the strips of tree seedlings for a second year and also weeded and sowed up blanks in the latter.

The first method had been tried only for a short time, but the results of the second method were promising, teak plants having attained a maximum girth and height of 6½ in. and 15 ft. respectively in 3½ years. In departmental sowings carried out on this principle the cost of formation during the first 3½ years, including collection of seed and weeding but not cost of supervision, amounted to Rs. 28–11–0 per acre, while the receipts from the produce of the field crops amounted to Rs. 32 per acre, leaving a profit of Rs. 3–5–0 per acre.

Broadcast sowing. Variable results have been attained with broadcast sowing. Where heavy weed-growth is not to be feared this method has been found to be decidedly successful as well as cheap, but where much weeding has to be carried out spacing in regular lines has usually been found preferable. Broadcast sowing, again, is suitable only for more or less level or gently sloping ground; on steep slopes broadcasted seed is liable to be washed away. In the Magwe district of Upper Burma, where the climate is dry, and heavy weed-growth is not so prevalent as in the moister districts, remarkable success has been attained by broadcast sowings of teak in *taungyas*. Here field crops are cultivated for two years, and this no doubt helps to eradicate weeds; the broadcasting of teak seed in the second year has resulted in well-stocked crops of teak. Mr. F. A. Leete[1] has advocated the more general adoption of broadcast sowing in Burma, and mentions that he has tried it in Pyinmana with great success; in 1910 he formed plantations half in regularly spaced lines at Rs. 10 per acre and half broadcast at Rs. 2 per acre, and in January 1912 he found equally good results in both. He notes that on steep slopes dibbling in lines is preferable, since broadcasted seeds are liable to be washed away. Subsequent reports from Pyinmana, however, indicate that these broadcast sowings gave some trouble in weeding, and in 1916 they were not so uniformly stocked as in the case of sowings in regularly spaced lines.

In June 1908 broadcast sowing of teak along with paddy was carried out in unprotected forest near Hmyachaung in the Tharrawaddy district; the area was burnt in 1909, and at the end of May 1909 two sample plots showed 1,360 and 1,760 seedlings per acre. Very little weeding was found necessary, and the cost amounted to about Rs. 2 an acre. This method imitates nature

[1] Ind. Forester, xxxviii (1912), p. 374.

in the matter of restocking abandoned cultivation with crops of teak, and deserves further trial.

A successful experiment in broadcast sowing was carried out in 1896 near Pinmadi in the Mohnyin reserve of the Katha district, Upper Burma. A patch of teak forest was heavily girdled, and the area was burnt and sown broadcast with teak seed. In the following year blanks were recleared and sown, the cover was thinned out, and the area was extended to 7·7 acres. The plantation was thinned in 1906, and in 1910 was reported to be well stocked with straight poles.

Broadcasting on ploughed land is said to have given good results in some cases in the Satara district of Bombay.

Dibbling. Under the head of 'dibbling' may be comprised operations for introducing teak or increasing its proportion over a given area by placing seed in the ground, not over continuous cleared areas of some extent as in the case of ordinary sowing, but in scattered gaps or comparatively small clearings within the forest. The dibbling of teak seed in the forest has been carried out for many years in various parts of Burma, but there has been very little to show for all the time, labour, and money spent on the work. Evident causes of failure in many cases are the fact that the dibblings have been carried out under cover of a forest canopy, that the seed has been buried too deep, or that it has been put into the ground too late in the season. If there is to be a reasonable chance of success dibbling should be carried out in open gaps or clearings, while the seed should be put into the ground before the commencement of the early showers preceding the monsoon, and should be very lightly covered. Even so, the success of the work depends on subsequent regular weedings, and here the trouble and expense of establishing crops of teak on any scale by this method at once becomes apparent, for however carefully the patches of dibbled seed may be marked they are often difficult to find subsequently, and the time occupied in searching for and weeding each individual patch of seedlings, should germination prove successful, in the great majority of cases renders the expense of this work quite out of proportion to the results attained. Moreover, the seedlings resulting from dibblings in the forest seldom show the vigour and rapid growth of those raised in *taungya* plantations, where the working of the soil and its enrichment with ashes greatly stimulate growth, and in consequence seedlings raised in forest dibblings take longer to outgrow weeds and are therefore subject to suppression for a longer time. Again, those plants which survive the first few years in small gaps in the forest require constant attention subsequently, for unless the canopy is kept open, bamboo and other growth being cleared, these plants must inevitably become suppressed.

In a moist climate like that of Burma, dibblings of this kind cannot be justified except for the purpose of increasing the quantity of reproduction over definite areas where concentrated regeneration is in progress, and where the intention is to remove the overhead canopy within a comparatively short time; in such cases weedings would be carried out systematically over the whole area, and the time occupied in searching for and weeding isolated patches would be saved. Experiments in Pyinmana have shown that dibblings have succeeded better in forest annually burnt over than in fire-protected

forest. Again, in the Ataran forest division in 1909 teak seed was dibbled in an old clearing about one acre in extent, and half the area was allowed to burn over, while the remainder was protected from fire; in the burnt half the result was fair, while in the protected half complete failure resulted. This indicates that fire may prove to be a useful aid to the dibbling of teak in the moist types of forest met with in Burma.

In the drier types of forest in Bombay dibblings followed by the subsequent loosening and mulching of the soil round the resulting seedlings for two or three years has proved fairly successful in places, though better results have been attained with transplants.

Tending of teak plantations. The three main classes of tending operations in a teak plantation are weeding, cleaning, and thinning. The distinction between weeding and cleaning is not always clear, and the application of the terms varies locally. As a rule the term 'weeding' is applied to the removal of weeds, often of a herbaceous or shrubby nature, during the earlier life of the plantation, and particularly during the first three or four years, while the term 'cleaning' denotes the removal of inferior tree species and bamboos which threaten to suppress the teak at a later stage. The term 'thinning' is used here in a purely silvicultural sense, irrespective of whether the operation is remunerative or not. Except in dry localities, where they may sometimes be dispensed with, weedings are essential to the establishment of the young crop. Their number, frequency, and intensity depend on the nature and luxuriance of the weed-growth, and this in turn depends largely on the rainfall, though other factors also operate, for instance the fertility of the soil; thus weeding is usually of a heavier nature on the fertile soil which previously supported tropical evergreen forest than on less fertile ground. The procedure for many years in the plantations of the Tharrawaddy district of Burma, where the normal rainfall varies from about 60 to 80 in., has been to weed annually for four years, including the year of sowing, and thereafter to weed or clean every alternate year until the first thinnings, about the tenth year. Thereafter cleanings are carried out at intervals of five years. In some cases two weedings are necessary during the first year.

Weeding is always carried out in the rainy season, when weed-growth is most luxuriant. In Burma clean weeding is considered unnecessary, the aim throughout the course of weeding and cleaning being to keep the heads of the teak plants well free, but not to lay them bare. In the weeding of the year after sowing or planting duplicate stems are removed and badly shaped and damaged stems are cut back flush with the ground. In the cleanings inferior species and bamboos which threaten the teak are cut out, or it is often found sufficient and even desirable to cut them at some distance from the ground. During the weedings and cleanings all climbers are cut, and the boundaries of the plantations should be kept clear of encroachment by the surrounding jungle, if necessary by maintaining a completely clear line round the boundary. In the Nilambur plantations the lines are clean weeded during the first season, the soil being loosened and the weeds pulled out; this is found to stimulate growth and keep down weeds to such an extent that subsequent weeding is of a light nature. As a rule there are three weedings in the first year, one or more in the second year, and none in the third year except in areas of the

third quality; on good soils the average height of the teak crop after three years is 16 to 22 ft., and weeds are killed out.

In Java the *alang* grass (*Imperata arundinacea*, Burmese *thekkè*) is a great scourge in young plantations. In order to prevent its ingress and to avoid the expense of hoeing, *Leucaena glauca* is sown between the lines of teak; this plant keeps the soil clean, and is ultimately killed out by the teak.

The frequency, intensity, and conduct of thinnings in teak plantations are matters on which opinions differ to some extent, and the conduct of thinnings must naturally vary in detail with local conditions. It is generally held that thinnings should commence early, that is, at an age of about 10–12 years, or even sooner, and should be carried out lightly but frequently up to an age of about 25 to 30 years, after which plantations should be thinned somewhat more heavily and at gradually increasing intervals of time. In fast-growing plantations it has been found advisable to thin at intervals of five years. In Burma thinnings are ordinarily carried out at intervals of ten years, but it is recognized that in the case of the younger plantations this interval is too long, and has been adopted for the time being only because of the paucity of trained staff. In Travancore, according to Bourdillon, thinnings commence in the seventh year, and are repeated in the ninth, twelfth, sixteenth, and twentieth years, and thereafter every fifth year.

The scheme of thinnings for the Nilambur plantations has been recently revised under Mr. R. Bourne's working plan. Generally speaking, in areas of qualities I and II, thinnings under this scheme will commence at an age of five years, and will be repeated at intervals of five years up to an age of fifteen years, and thereafter at intervals of ten years up to an age of forty-five years, after which no further thinnings will be carried out; in areas of quality III thinnings will commence at an age of ten years, and will be repeated at intervals of five years up to an age of twenty-five years, and thereafter at intervals of ten years up to an age of forty-five years, after which no further thinnings will be carried out. The first thinning in each case is purely mechanical, every alternate plant being removed from the lines in such a way as to leave the remaining plants evenly spaced in squares, but each occupying double the area it occupied previously. The last thinning is in the nature of an increment felling; the number of stems left to form the final crop must vary with the state of the crop, but the number per acre is roughly 35 on soils of quality I, 45–50 on soils of quality II, and 65–70 on soils of quality III. The yield table given below (p. 763) under 'statistical' shows the average number of stems per acre left after thinning, and the intermediate yields at different ages in the Nilambur plantations.

Mixtures in plantations. The question of mixtures in teak plantations is one which deserves further study. Teak is not a good soil-improver, and it would often be advantageous silviculturally, where a natural underwood of bamboos and woody species does not make its appearance, to introduce an underwood artificially, choosing where possible a useful species whose cultivation would be remunerative. Various species have been tried in mixture with teak, but where the companion species has been introduced along with it, one of the two has almost invariably failed through being outgrown and suppressed by the other. Where insect damage is to be guarded against,

therefore, it would be preferable to create small blocks of pure teak, alternating with similar blocks of other species. Where the object is to introduce a soil-protection wood or a useful accessory species it would be preferable to employ a shade-bearer and to introduce it beneath the teak, thinning the latter out more heavily than would otherwise be the case. In Coorg the system, tried in recent years, of sowing teak, *Dalbergia latifolia*, and *Pterocarpus Marsupium* in alternate lines has not proved altogether satisfactory, since the slower initial rate of growth of *Dalbergia* and *Pterocarpus* necessitates tending for some time after the teak is established, while later these two species outstrip the teak in height-growth and may give trouble ; it has therefore been proposed to form pure plantations of these three species in alternate blocks not exceeding 50 acres in extent. *Artocarpus hirsuta* has been introduced below teak with considerable success in Travancore, and there are other useful species which might be tried in this way, such as *Hopea parviflora* or *Xylia xylocarpa* on the west coast and *Xylia dolabriformis* in Burma. In Java *Schleichera trijuga* is looked upon as a very useful soil-protective species under teak.

In Burma mixed plantations of teak and cutch (*Acacia Catechu*) have been formed on a fairly extensive scale ; these species do not mix well, but tend to separate out into pure groups, the teak claiming the ground suitable for it, and the cutch occupying the less favourable ground. When such plantations are made nowadays it is usual, therefore, to mix the two species by groups, sowing the teak on the better-drained and more fertile ground and the cutch on the less well-drained or poorer ground. Other species which have been tried in mixture with teak in Burma are *Xylia dolabriformis* and *Pterocarpus macrocarpus*, both on a very small scale, and without success ; mahogany, which, as was found also at Nilambur, proved unsuitable for mixture with teak ; *Cassia siamea*, which was sown in alternate lines with teak, soon overtopped the latter, and had to be cut out ; *Millettia Brandisiana*, result not recorded ; and mango, which in course of time disappeared for some reason not recorded. In the Katha district of Upper Burma recent experiments have been carried out in interplanting teak with *Cassia Fistula*, *Xylia dolabriformis*, *Dysoxylum binectariferum*, *Gmelina arborea*, *Bombax insigne*, *Cedrela Toona*, and *Lagerstroemia Flos-Reginae*. Of these the last two, and particularly *Lagerstroemia*, show promise. *Gmelina arborea* was found to grow too fast and to branch too freely for mixture with teak in alternate lines.

Certain mixtures have been tried in the Andamans. Between 1883 and 1889 teak and padauk (*Pterocarpus dalbergioides*) were sown 4 ft. apart in alternate lines 9 ft. apart, but the teak soon outstripped and suppressed the padauk. In 1913 teak was sown 3 ft. apart in lines 24 ft. apart, padauk and *Albizzia Lebbek* being sown broadcast between the lines of teak. In the same year teak was planted with a spacing of 12 ft. by 6 ft. with casuarina between, but the latter failed.

Silvicultural treatment. The tending of teak in artificial crops has already been dealt with ; it will be convenient here to deal with the management and silvicultural treatment of teak forests under separate heads : (1) coppice systems, (2) high forest systems of the selection type, (3) high forest systems with concentrated regeneration, (4) teak in relation to bamboos.

1. *Coppice systems*. In the drier parts of the Indian Peninsula, where

teak does not reach any great size, the system of coppice-with-standards is largely followed. This is particularly the case in the Bombay Presidency, where a large proportion of the teak-bearing forests are worked under this system. Coppice-with-standards is also the system followed in parts of Madras and the Central Provinces.

In Bombay the coppice rotation hitherto most commonly adopted is one of 40 years, though the rotations actually vary from 30 to 60 years, and recently the long rotation of 80 years has been adopted in two of the Kanara working plans. The rotation for standards, in the few cases where it has been fixed, is one of 60 or 80 years, being twice the rotation for coppice. The number of standards to be left, according to working plans prescriptions, varies from 15 to 45 per acre. In the Golihalli-Godoli teak forests of Belgaum the system of simple coppice is in force, standards being reserved only where the growth is exceptionally good. The opinion is gaining ground in Bombay that some of the forests hitherto worked under coppice-with-standards, particularly the Thana forests, could be worked more profitably and successfully under simple coppice with a long rotation, namely 80 years, no standards being reserved : this does not, however, apply to very steep or poorly stocked hill-slopes. This opinion has been formed on the ground that clear-fellings are more suitable for teak than any form of two-storied forest, that teak coppices to an advanced age, and that if cultural operations are properly carried out there is no necessity to retain seed-bearers. In areas worked as coppice-with-standards, again, the opinion seems to be now prevailing that 15 to 20 standards per acre, as a maximum, are ample if the coppice is not to suffer from domination.

In the Central Provinces a system known as partial coppice or coppice selection is practised, for the most part in remote coupes where there is only a limited demand. Its main object is to replace deteriorating and badly shaped stems by straight coppice shoots, and with this end in view such stems are coppiced flush with the ground, even where the coppicing of the whole coupe is impracticable. At the same time, standards are reserved as in the ordinary coppice-with-standards system. The main felling is followed by the systematic cutting back of badly shaped or otherwise undesirable stems. These cutting back operations for the improvement of the young crop are found to be most useful in the forests of the Central Provinces, where the teak is so often misshapen, owing to past maltreatment.

Although teak coppices extremely well, seedling reproduction in the Central Provinces is often very poor, and it is by no means certain that repeated coppicing can be carried out indefinitely ; this has given rise to some apprehension as to the future, and has indicated the desirability of introducing seedling reproduction artificially in coppice coupes where natural seedling reproduction is wanting.

Mr. A. G. Edie [1] has recorded the results of an experiment carried out in the pole areas of North Kanara to find out the effect of thinning out the weaker shoots of a stool on the subsequent growth of the remaining and stronger shoots. In four plots altogether 131 stools were thinned and 131 left unthinned. The resulting shoots were measured the year of thinning and subsequently at an interval of two to four years, but in the case of the unthinned stools only

[1] Ind. Forester, xlii (1916), p. 157.

the dominant shoots were measured, corresponding to those left in the case of the thinned stools. The following statement shows the results of the measurements :

Tectona grandis : measurements in thinned and unthinned coppice, North Kanara.

Plot No.	Age at time of thinning.	Interval after which remeasurement was made.	Percentage of shoots thinned out.	Increment per annum. Height. Thinned.	Height. Unthinned.	Girth. Thinned.	Girth. Unthinned.
	years.	years.	per cent.	ft.	ft.	in.	in.
1	3	3	64	2·11	2·19	1·13	1·05
2	7	2	67	1·05	0·98	0·82	0·62
3	9	4	..	..	..	0·82	0·77
4	15	4	..	..	..	0·45	0·35

These figures show a girth increment in favour of the shoots of the thinned coppice, though the effect of the thinning is hardly so great as might be expected. Mr. Edie remarks, regarding this experiment, that thinnings in coppice are probably advisable, but that these should not be undertaken until the coppice is at least ten years old, partly in order to preserve the cover and partly because if shoots are thinned out in young coppice new shoots take their place.

2. *High forest systems of the selection type.* The treatment under high forest of vast areas in which teak, a strong light-demander, occurs scattered among numerous other species in constantly varying types of forest in which bamboos often play an important part, is by no means an easy problem, and the method of treatment hitherto applied almost universally to the extensive teak forests of Burma and to the better classes of forest on the west coast of India is in no way a solution of that problem. This method of treatment has been termed the selection system, but it is not the true selection system of Europe, since it does not provide for the attainment of normality or ensure a sufficiency of reproduction, nor does it even take the silvicultural requirements of the teak into consideration. Briefly stated, this method of treatment consists in working over a given tract of forest in a definite felling cycle and cutting out those teak trees which have reached a certain minimum girth, with the proviso that where teak reproduction is absent, seed-bearers should be left ; in most cases the maximum number of trees to be removed in any year or period of years is fixed. This system was adopted in Burma in the early days of forest organization as being the only practicable method of utilizing, under some sort of control, the stock of mature teak over the extensive areas of forest to be dealt with. As a provisional method of treatment it was the only one to adopt under the circumstances. Yet with the exception of one or two recent innovations, which will be noted below, it has continued to be the system in force throughout Burma down to the present day, and it must continue to be practised over considerable areas for some time to come, since the introduction of more rational systems of management over the vast areas to be dealt with must take time.

It has never been denied that the cutting out of all mature teak trees from among their numerous associates will in time lead to a serious diminution of the principal species, and hence working plans have prescribed the removal of inferior species in the interests of immature teak of all ages. But in actual

practice it has been found quite impossible to carry out these improvement fellings, as they are termed, on anything like the scale necessary to keep up with the felling of teak trees, more especially since experience has shown that in the case of young teak still in danger of suppression from weeds and bamboos a single felling is insufficient, and cleanings require to be repeated, it may be several times, before the young teak are out of danger.

The note of alarm in respect of selection fellings in Burma was first sounded after the adverse effects of continued fire-protection on the establishment of teak reproduction came to be realized, and the conclusion was reached that the combination of continued fire-protection with selection fellings would ultimately lead to the extinction of teak over large areas of forest. The argument that the abandonment of fire-protection will bring about the desired result without any alteration in the method of treatment will not hold, for the constant cutting out of the teak, without the possibility of carrying out improvement fellings for the benefit of that species on anything like the scale necsssary, is bound eventually to deplete the stock of teak. Again, if the reproduction and establishment of the teak crop is to receive special encouragement, some regard must be had for the requirements of the species in such matters as exposure of the soil to the sun for purposes of germination, clearance of overhead cover to afford abundance of light and to prevent mortality from drip, and repeated weeding and cleaning. Finally, in most of the forests in which teak has hitherto been worked under selection fellings, the proportion of that species might be largely increased without undue risk of insect or fungus attacks, and much fertile ground which is at present unproductive might be utilized profitably. These considerations, apart from other advantages to be secured from concentration of working, have within recent years led to a fairly general consensus of opinion in Burma that the selection fellings hitherto in vogue should be superseded, when and where circumstances will permit, by some system of concentrated regeneration whereby the proportion of teak will be not only ensured but increased.

A brief account of the method of selection fellings hitherto practised in teak forests may be of interest. In Burma it has long been the custom to girdle teak trees three years before felling them ; this girdling, which consists of ringing them completely down to the heartwood near the base of the tree, is carried out primarily with the object of rendering the timber buoyant for floating purposes, but it also serves to season the timber before felling and extraction. Trees are selected for girdling, provided they have attained the prescribed minimum girth and are not required as seed-bearers, and are felled at least three years later. The exploitable girth most commonly adopted in Burma is 7 ft., or 6 ft. in dry types of forest, but in some cases it is fixed at $7\frac{1}{2}$ or 8 ft. The age corresponding to a girth of 7 ft. is with very few exceptions estimated to be from 150 to 180 years. The exploitable age is divided into a convenient number of periods, which actually vary from 20 to 40 years, but are for the most part 30 years in duration ; the period is equivalent to the cycle during which fellings go completely round the whole area. The period is divided into sub-periods, which usually vary from four to eight years each, and corresponding sub-periodic blocks are laid out on the ground. The object of these blocks is to afford elasticity of working, in that girdling is not

confined each year to a definite annual coupe, but may be carried out in the prescribed sub-periodic block at any time during the sub-period.

The better types of teak forest in Bombay and Madras are worked as a rule under selection fellings of a similar kind. In North Kanara and Thana the exploitable size fixed is a diameter of $18\frac{1}{2}$ or 24 in., or a girth of 6 or $6\frac{1}{2}$ ft. The rotation, where calculated, varies from 120 to 160 years, and the felling cycles adopted vary from 15 to 30 years. The yield is usually fixed by number of trees, and in some parts of North Kanara girdling is carried out two or three years before felling.

In the Allapilli forest of South Chanda in the Central Provinces teak is worked under selection fellings with an exploitable girth of 6 ft., corresponding to an estimated mean age of 175 years.

Improvement fellings of the selection type are carried out in parts of the Central Provinces and Madras, and in various parts of Bombay, particularly in Khandesh. These fellings have for their object the removal of over-mature, badly shaped, and otherwise undesirable stems, and are carried out under a definite felling cycle, which ordinarily varies from 10 to 30 years, but is in two cases as long as 45 years. These improvement fellings are often followed by cutting back operations in the young crop, with the object of producing straight coppice-shoots.

It will be convenient to allude here to the tending operations, termed improvement fellings, which are carried out as far as staff and labour permit in the teak forests of Burma. These fellings are of two separate classes: (1) 'O' improvement fellings, made in the interests of the old crop, and (2) 'Y' improvement fellings, made in the interests of the young crop. The 'O' fellings are in the nature of a thinning in a mixed crop, and apply to trees which have passed out of the pole stage; they are carried out as soon as possible after the extraction following the main fellings, and the intention is to repeat them at intervals of 15 years, though this interval is recognized to be too long in many cases. The object of these fellings is to free promising stems of teak and other valuable species by the removal of undesirable stems which are interfering with their development, care being taken, however, not to open the canopy to such an extent as to cause an invasion of weeds.

The 'Y' improvement fellings have for their object the establishment of such natural reproduction of teak and other valuable species as may be found on the ground. They are in the nature of weedings and cleanings, and consist of the removal of weeds, bamboos, and inferior tree species which are interfering with the development of seedlings, saplings, and poles. The cutting back of badly shaped, damaged, or suppressed saplings is carried out at the same time; it has been found that badly suppressed saplings, if freed, do not as a rule recover their vigour, whereas if cut back they may send up strong new shoots. Where necessary, undesirable trees in the overhead canopy may be removed, provided that the canopy should not be opened to the extent of inducing heavy weed-growth which would suppress existing teak seedlings and saplings. These weedings and cleanings are carried out as soon as possible after the extraction following the main fellings, and are repeated as often as necessary and until the young crop is safe from suppression. As these operations are of an intensive nature they are confined to areas where there is

sufficient natural reproduction present to warrant their execution, and to areas from which extraction is easy. Within the area operated over, places containing no teak, but which are suitable for its growth, are regenerated artificially by the *taungya* system. These cultural operations, combined with artificial reproduction within the areas operated over, are interesting as showing an attempt to regenerate definite areas, and may be regarded as a transition stage towards the adoption of a regular system of concentrated regeneration tending towards the creation of even-aged crops.

These 'Y' improvement fellings have now been in operation in Burma for some years, and the experience gained so far indicates that they can rarely, if ever, justify themselves financially if they are carried out in forest under continuous fire-protection, and unless they are considered as a means towards the complete regeneration of definite areas with the aid of fire and in conjunction with the complete removal of overhead cover in the manner described below; even so the *taungya* system of regeneration has proved to be cheaper and more efficient. It has been found that 'Y' improvement fellings in fire-protected forest may be the means of saving from suppression, at considerable cost, saplings which are already established; they do not result in the appearance of new seedlings. In Tharrawaddy 'Y' improvement fellings repeated for four or five years have been found to cost Rs. 5 to Rs. 10 per acre for weeding and cleaning only, without the clearing of overhead cover, which is necessary for the proper development of the young growth, and in certain cases they have cost as much as Rs. 21 to Rs. 37 per acre when repeated for five years, with results quite incommensurate with the high cost and far less successful than would have been attained at a lower cost by the aid of *taungya* plantations.

3. *High forest systems with concentrated regeneration. Dutch East Indies.* The method of treatment of the teak forests in the Dutch East Indies has been described in a note by Mr. R. C. Milward.[1] The teak grows remarkably pure on the chalky soil on which it is commonly found, and efforts are made to encourage a mixture of other species, of which *Schleichera trijuga* is considered the most suitable, as it stands shade and keeps the soil in good condition. The present method of treatment is by clear-felling in plots of between 25 and 50 acres, followed by natural reproduction by seed or coppice, which is supplemented by artificial reproduction. The rotation arrived at is 100 years on good soils and 80 years on poor soils, the average diameter attained on the former being 24 to 32 in. The trees are girdled two years before felling. Sometimes the coupe is burnt over before felling, in order to assist the germination of the teak seed on the ground. Burning is in any case carried out after extraction is completed, the refuse being piled up against the old stumps to prevent the growth of coppice-shoots, which are not desired from these stumps. All the smaller stumps are then coppiced. Only one good coppice-shoot is left on each stool, the others being bent or half broken down a year or so after coppicing, in order to cover the ground. The growth of grass which tends to spring up on these large clear-felled areas is looked on as a disadvantage, and hence, although this system is very successful and comparatively easy, the Dutch foresters are on the look-out for some system which will prevent the

[1] Note on the Forests of Java and Madoera of the Dutch East Indies, 1915.

invasion of grass, such as natural reproduction in groups. *Leucaena glauca* is sown with the view of keeping down a heavy growth of grass.

Mohnyin and Bilumyo forests. The Mohnyin and Bilumyo forests in the Katha district of Upper Burma have already been described. They are situated near each other, on fairly level ground, and have an aggregate area of 27,489 acres. Teak occupies less than one-third of the area, but where it occurs it constitutes a greater proportion of the stock than is usual in the teak forests of Burma, becoming almost pure in places. The absence of bamboos over most of the area further increases the dissimilarity between these forests and the usual types of teak forest in Burma. The teak trees attain very large dimensions, and large trees are much in excess. A feature of these forests, which for some time caused uneasiness, is the almost entire absence of natural reproduction of teak. With the view of devising means of inducing reproduction, experiments were commenced by the late Mr. J. Messer about 1898 and continued for some years; they were subsequently carried on in turn by Messrs. McHarg and Blanford. These experiments demonstrated the fact that abundant natural reproduction, from teak seed lying dormant in the ground, could be induced by opening the canopy and by completely clearing and preferably burning the undergrowth. They showed, however, that the seedlings were rapidly killed off during the rainy season by the drip from overhead trees and by the weeds which sprang up. This indicated the procedure to adopt, namely, to remove all overhead cover possible, to cut and burn the undergrowth, and to weed and clean the young teak crop for two or three years. Figs. 287, 288, and 289 show the profusion with which natural reproduction of teak is capable of establishing itself under this treatment in areas in which it is entirely absent where these measures are not taken.

A working plan based on the results of these experiments was prepared by Mr. Blanford, and came into force in 1910–11, the fellings being prescribed for 20 years. The rotation adopted is 180 years, corresponding to an average girth of 8 ft., and is divided into nine regeneration periods of 20 years each, the periodic blocks being so allotted as to contain as far as possible an equal stock of teak. The working plan prescribed that periodic block I, to be regenerated first, should be divided into four 5-year coupes or compartments, corresponding to 5-year sub-periods, regeneration fellings being carried out by felling over the whole compartment in the first year of the sub-period, or failing this by the second year, all teak except promising compact groups of young trees. This prescription has subsequently been modified to allow for annual instead of 5-yearly coupes, in order to ensure complete extraction in one year over a definite area. The working plan prescribed the retention of exceptionally well-shaped clean-boled teak below 6 ft. in girth, even if isolated, but this has been found to be unsatisfactory, and is not acted on. The aim is to effect as complete a clearing as possible in order to prevent seedlings being killed by drip from overhead trees. All felled material which can be disposed of is at once extracted, after which the whole area is thoroughly burnt, all unburnt material being cut up, piled, and reburnt; if complete burning is not effected the first year, burning has to be repeated the second year. The working plan prescribed burning for two years prior to girdling, but this has proved to be a mistake, since it induces the germination of numerous

FIG. 287. Natural reproduction of teak induced by clearing overhead canopy, cutting and burning undergrowth, and weeding young plants, Mohnyin, Upper Burma: plants of 2 rains' growth.

FIG. 288. Natural reproduction of teak induced by clearing overhead canopy, cutting and burning undergrowth, and weeding young plants, Mohnyin, Upper Burma: plants of 3 rains' growth.

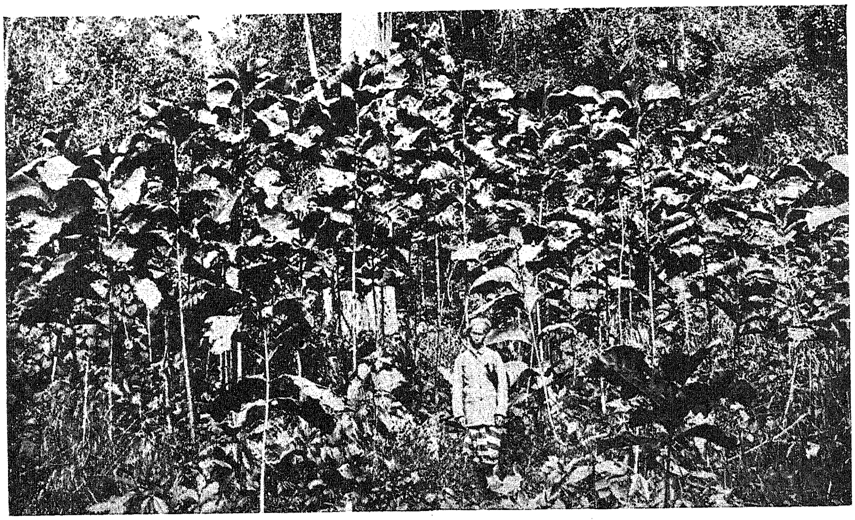

Fig. 289. Natural reproduction of teak induced by clearing overhead canopy and undergrowth, Mohnyin, Upper Burma: area not burnt but weeded regularly: plants of 4 rains' growth.

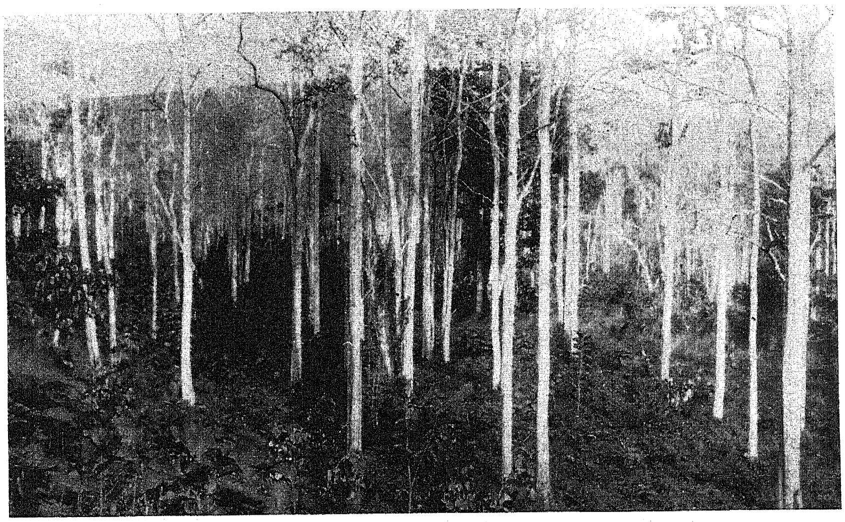

Fig. 290. Regeneration fellings in Mohnyin forest, Katha, Upper Burma: a regenerated area after the second rainy season, with teak seedlings plentiful: girdled trees not yet removed.

Fig. 291. Natural reproduction of teak 1 year old in upper mixed forest, induced by clearing overhead cover, cutting bamboos, thoroughly burning, and weeding the resulting teak seedlings, North Toungoo, Burma.

teak seedlings which die owing to want of light and the presence of weeds, while the supply of seed lying dormant in the ground is reduced in quantity. The seedlings, which spring up in abundance as a result of the clearing and burning, are weeded from the commencement, and weeding requires to be continued for two or three years, or until the young plants are safe, after which periodical cleanings are necessary. As many as three weedings may be required during the first rains. It was hoped that annual burning of the young crop might serve to dispense with these expensive cleanings, but an experiment to this effect resulted in failure. Fig. 290 shows a regenerated area after the second rainy season, before the removal of the girdled trees. All blanks are planted up during the first rainy season with natural teak seedlings spaced 6 ft. by 6 ft. It is not safe to postpone this work for a single year, owing to the profusion with which grass springs up on cleared areas. Three years after girdling the girdled teak trees are felled and extracted. This does great damage to the young crop, and injured stems require to be cut back. It has, therefore, been decided experimentally to girdle the teak three years before the regeneration fellings, and to fell and extract it immediately before burning.

In periodic blocks II to IX, selection girdlings are prescribed which will pass completely over the area in the 20 years' period; no tree under 10 ft. in girth will ordinarily be girdled unless it is obviously deteriorating.

Although the success of this system has been amply demonstrated, further experiments are still in progress with the view of reducing the cost of regeneration and of introducing mixtures of other species in order to avoid raising pure crops of teak. An interesting account of these operations has been written by Mr. H. R. Blanford.[1] The results of a recent experiment in regeneration under the *taungya* system bid fair to modify completely the operations prescribed in the working plan. It has been found that natural reproduction of teak, with an admixture of other species, springs up in abundance on areas cleared for temporary cultivation, and where reproduction is wanting the blanks can be easily filled up with transplanted natural seedlings. Regeneration under the *taungya* method very considerably reduces the cost; on a Kachin *taungya* of 22 acres a complete and vigorous young crop has been established and brought through the first season at the low cost of Rs. 2 per acre. Under the prescriptions of the working plan as subsequently modified, the cost of regeneration from 1910–11 to 1917–18 has amounted to Rs. 40 per acre, which is prohibitive, although culturally the work has been successful; this may be compared with the cost of a very successful *taungya* plantation formed in 1910–11, which amounted during the same period to about Rs. 19 per acre.

Burma teak forests in general. The great majority of the teak forests of Burma are characterized by the presence of an under-story of bamboos which greatly affects the treatment. The question of introducing some system of concentrated regeneration in these forests was considered at a conference held in Burma in 1910. The general scheme of management tentatively approved by the conference provided for the division of the rotation into periods. Periodic block I was to be treated under regeneration fellings with intensive weedings and cleanings, while the other periodic blocks were to be worked by selection

[1] Ind. Forester, xliii (1917), p. 339.

fellings. It was decided that regeneration fellings should consist of one main felling followed by subsidiary improvement fellings carried out where necessary at intervals of five years. The main fellings would consist of the girdling of mature teak trees, with a minimum girth of 7 ft. in moist and 6 ft. in dry forest, while other species would be completely cleared over young teak. The girdling of undersized teak was not contemplated except where necessary, in order to free promising groups of young trees and advance growth. Plantations and cultural operations, that is, repeated weedings and cleanings, and as far as possible also bamboo extraction and road-making, in order to encourage the utilization of species other than teak, would be concentrated in this block. The use of fire to stimulate natural reproduction was also contemplated. In the other blocks it was proposed to carry out selection fellings of teak and other saleable species. A system on these lines aims at increasing the proportion of teak and other valuable species, but not at creating even-aged crops of teak, though it tends towards the ultimate establishment of even-aged crops; at present such crops would be produced only where plantations are formed.

Since 1910 a great deal of useful experimental work in the natural regeneration of teak forests in Burma has been carried out, and as a result the opinion is gaining ground that the most satisfactory way in which to treat the natural teak forests of Burma wherever conditions permit is to produce even-aged young crops, though not necessarily pure crops of teak of large extent. For this purpose complete clearance of the overhead canopy is necessary, and it is accordingly considered advisable as far as possible to confine this intensive form of regeneration to localities where at least the more valuable species of trees other than teak are marketable. For this reason the allotment and sequence of regeneration areas should be made in conjunction with schemes of roads or other export works. It has further been found to be of great advantage to reduce to a minimum the time taken to regenerate a given area completely, that is, the time from the first regeneration felling to the complete establishment of the young crop. For the production of even-aged crops it will be necessary to sacrifice immature teak trees, but the ultimate gain, in the production of a largely increased future stock of teak, is held to justify this sacrifice. Theoretically the areas to be placed in periodic block I, to be regenerated first, should be those containing most mature trees and least reproduction. But actually it is considered advisable to maintain a supply of mature teak to provide for the outturn some years hence, owing to the depletion of many of the important teak tracts by heavy fellings in the past and to the diminution of the number of teak trees outside reserved forests with the extension of cultivation. This being so, it is held to be preferable to regenerate first (1) areas which are capable of producing teak of good quality, but in which teak is scarce or absent, and (2) areas containing much established reproduction, including plantations. Allotment to other periods is as a rule unnecessary, except that periodic block II should be allotted tentatively and the exploitable size in it should be placed higher than in the other blocks, in order to retain as many teak seed-bearers as possible, and to maintain the future yield.

As regards the method to be employed for regenerating a given area, the

method of *taungya* plantations, from the point of view of efficiency and economy, has proved far superior to any other method yet devised, however successful. These plantations should, if properly carried out, seldom cost more than Rs. 20 per acre to establish completely, and where no rewards are given for raising the young crop of teak they should cost a good deal less. Experimental work in obtaining natural reproduction by felling, burning, and weeding has shown that crops far less fully stocked cannot be raised except at a considerably higher cost than in the case of *taungya* plantations. For the systematic formation and upkeep of these plantations on a large scale the establishment of forest villages will in most cases be necessary. This will ensure a permanent supply of forest labour for work other than that connected with plantations, while in addition the food of the labour force will be produced on the ground.

Failing *taungya* plantations, experiments carried out in the upper mixed forests of the Pegu Yoma so far indicate the following to be the sequence of operations necessary to secure natural reproduction :

(1) The area should be fire-protected for two or three years before fellings are commenced, in order to ensure a plentiful crop of teak seed on the ground.

(2) All trees should be felled or girdled except those required as seed-bearers and compact groups of poles of teak and other valuable species which are not too old to form part of the future crop, but all solitary poles, including teak, should be cut, together with all bamboos and shrubby undergrowth ; this should be completed by the hot season.

(3) The whole area should be thoroughly burnt in the hot season, the fiercer the fire the better being the results ; it may be necessary to burn again for another year or two before a sufficient crop of young teak is secured.

(4) This felling and burning is usually followed by a good crop of young teak and other species where seed-bearers are plentiful and where the fire has been intense ; all trees standing on the area should be felled and removed during the cold season following the appearance of the young crop, or if teak is not to be felled green it should then be girdled, extraction being carried out three years later.

(5) The young crop should be weeded, usually three times during the first rainy season, and subsequently as often as necessary until it is established.

(6) After the extraction of girdled teak, damaged young growth should be cut back.

(7) After the burning the area should be fire-protected as long as weeding is necessary ; thereafter experience should determine whether it is better to continue fire-protection or to burn early in the season.

Fig. 291 gives an idea of the success with which natural reproduction has been obtained on an experimental scale in the Saing Yane reserve of the North Toungoo division by clearing the overhead cover, felling bamboos, thoroughly burning, and weeding the resulting natural teak seedlings.

A system of concentrated regeneration fellings somewhat on the lines just indicated is being introduced throughout the whole of the hill forests of Tharrawaddy. For the present the rotation is to be fixed at 120 years, divided into six periodic blocks of twenty years each. In the blocks not under regeneration, subsidiary selection fellings, with thinnings, will be carried out under

a felling cycle of thirty years, areas likely to be placed in periodic block II being excluded from girdling during the first twenty years.

Teak forests of the Indian Peninsula. In the moister and better types of teak forest in the Indian Peninsula, which have hitherto been worked under fellings of the selection type, there is scope for the introduction of concentrated systems of regeneration such as those which are being introduced in Burma, though the details must vary with local conditions. In the drier types of forest a commencement has already been made in Bombay by the system of tending and mulching natural seedlings in newly felled coupes, combined with artificial reproduction. Experiments on similar lines in Berar have indicated the necessity for removing overhead cover to prevent drip from overhanging trees, and this is a step towards the creation of even-aged crops over definite areas.

The Nilambur teak plantations. These plantations have recently begun to reach maturity, and it has been decided to fix the rotation at 70 years, which under conditions prevailing hitherto produces average girths of 6 ft., 4 ft. 9 in., and 3 ft. 7 in. on soils of first, second, and third quality respectively; under the new scheme of thinnings introduced recently these girths should be exceeded in the second rotation. The manner in which the various soil qualities are intermingled on the ground precludes the adoption of different rotations for the different qualities. The system of management is that of clear-felling with artificial reproduction by replanting. It has been found that on areas where clear-felling followed by burning of refuse has been carried out, plentiful crops of natural seedlings, sometimes of great density, make their appearance. These crops, however, are patchy, owing to the fact that the seeds are washed together on certain parts of the area and may be scarce or absent on other parts. The natural crops would no doubt flourish if left and tended, but it has been found better to ignore them and to replant with regular spacing, as weeding and early thinning are much facilitated thereby. Hence only those natural seedlings are retained which are required to replace failures among the artificially raised plants, and which happen to be situated somewhere near the blanks to be filled; all other natural seedlings are treated as weeds and removed.

4. *Teak in relation to bamboos.* In Burma, as well as in parts of India, the treatment of teak is intimately connected with a study of the habits of the bamboos associated with it. Some remarks on the habits of bamboos in general will be found under *Bambuseae.* In Burma these bamboos are of many different species and vary much in character and habit, and the question of obtaining adequate teak reproduction, whether naturally or artificially, involves many problems which are not always easy of solution. It will be convenient to deal with the question separately from the point of view of bamboos which are not in flower and those which are flowering or have flowered.

As regards bamboos which are not in flower, it has been demonstrated on many occasions in Burma that natural reproduction of teak can usually be obtained by felling the bamboos, opening the canopy and clearing undergrowth for some distance round seed-bearers, thoroughly burning all the cut material, cutting back saplings which are injured by fire, weeding for two or three years the teak seedlings which appear on the ground, and subsequently keeping them clear of overhead bamboos and other growth. Where thorough burning is not carried out, failure is almost invariable. An interesting

experiment in the clearing of bamboo, carried out by Mr. A. Rodger in 1916 in the South Nawin reserve, Prome, may be noted. The forest consisted of dense *kyathaung* (*Bambusa polymorpha*) on a cold northerly aspect, with a few mature teak and pyinkado (*Xylia dolabriformis*). The bamboos, 37 clumps in all, were cut in January for a distance of about 20 yds. round a teak seed-bearer; the cut material was burned in the ordinary course, the area not being fire-protected, and part of the cleared area was hoed up. There was an advance growth of 22 suppressed teak plants already on the ground, and these were marked. Next year all these had disappeared under the influence of the sudden clearing, but in their place no fewer than 123 new teak and 565 pyinkado seedlings had appeared; there was nothing to show that these were more plentiful on the hoed ground than elsewhere. These seedlings only required regular weeding and freeing from overhead bamboo cover to establish a promising young crop. This experiment is interesting as showing that teak natural reproduction can be established in a type of bamboo forest which produces trees of large size and straight growth, but in which natural reproduction is often scarce or absent owing to the heavy shade of the bamboo. The death of the pre-existing teak plants is also of interest. This does not always occur in freeing teak seedlings and saplings from overhead bamboo cover, and the effect probably depends on the extent of the change of conditions suddenly brought about by the clearing, on the vigour of the plants freed, and on the severity of the fire. Possibly cutting back the saplings immediately before or immediately after the burning might assist in their survival.

The effect of opening and burning bamboo forest is illustrated by the following quotation, relating to the Tharrawaddy forest division, from the Burma Forest Report for 1916–17:

'In one plot of *kyathaung* (*Bambusa polymorpha*) forest which had been heavily worked over in 1915–16 by bamboo-cutters, who had left much trash behind them, an accidental fire occurred. Owing to the dry bamboo trash the fire was more than usually fierce. In the following December the Range Officer drew the Divisional Officer's attention to the number of new teak seedlings which he had observed and marked. So many had come up that it was hardly possible to believe that they had not been artificially sown, since the seed-bearers stood at some little distance. In another "Y" felling plot in the same compartment the same fire had caused some dry trees to fall and burn clear lanes through the young growth of *pyinkado* and bamboos. Several of these lanes contained a row of new teak seedlings which at first sight appeared to have been lined out by hand.'

As regards the tending of teak plants in bamboo forest, periodical cutting of the bamboo is necessary until they are free from danger of suppression, and this work is costly. An experiment carried out recently in Pyinmana showed that good results can be obtained by cutting the bamboo clumps about 5 ft. from the ground; they then develop side branches which keep down weeds. New culms which appear are cut off annually at the same height.

The importance of the flowering of the bamboo in connexion with the reproduction of teak lies in the fact that in the case of the more important species gregarious flowering takes place, usually at long intervals, over

considerable areas of forest, and after flowering the bamboos die; the dead culms then fall by degrees and, in burnt forests, become consumed by fire. The admission of light and heat caused by this opening of the bamboo cover stimulates the natural reproduction of teak provided fire is admitted. The influence of bamboo flowering on teak reproduction has at times been called in question, but it is now known from various recorded observations to be a fact that it has a very decided influence. I have myself observed its undoubted effects in the Pyinmana forests, following on a general flowering of *Cephalostachyum pergracile*. Mr. J. W. Oliver [1] has recorded the following statement: 'Where there are a sufficient number of parent seed trees an intense fire following the flowering and dying of bamboos generally gives rise to extensive reproduction of teak, without the aid of artificial sowings. Instances of this may be studied in the Setkala reserve in the Bhamo division and in some of the reserves on the right bank of the Shweli river in the Ruby Mines division; the Nanme reserve is, I think, the particular locality I have in mind.' In the same connexion the following passage may be quoted from the Report on Forest Administration for the northern circle, Upper Burma, 1907–8: 'Observations made during the year show that the flowering of the bamboo, *tinwa* (*Cephalostachyum pergracile*), which has been advancing in a wave southwards over Upper Burma during the last four or five years, has had markedly beneficial results on teak reproduction.' In the following year the Report says: 'Observations of the year confirm the view expressed in the last Annual Report that the reproduction of teak in areas in which bamboos have flowered and the débris been burnt, or allowed to burn, leaves little to be desired. On the other hand, where bamboos have flowered and the area has not been allowed to burn for fear of damage to contractors' logs and naturally dead and windfall timber, a tangled mass of vegetation consisting of creepers and weeds and old bamboo stems encumbers the ground, and not only prevents any fresh germination, but also hopelessly smothers any seedlings which might previously have existed.'

It is evident that in the types of forest met with in Burma the admission of fire is necessary in bamboo-flowered areas where natural reproduction of teak is desired. For how long, if at all, burning is necessary after the year of seeding of the bamboo will depend on local conditions and on the extent to which weeding and cleaning can be carried out. Young bamboo growth is far less adverse to the establishment of teak reproduction than certain other weeds—for instance, *Eupatorium odoratum*, *Alpinia*, *Strobilanthes*, gingers, &c.—but if it is fire-protected, young bamboos form very dense masses, which if cleaning cannot be carried out may do much harm by suppression.

Mr. C. B. Smales [2] notes that in areas in the Thayetmyo and Prome districts, where *Dendrocalamus strictus* and *Bambusa Tulda* had recently flowered and where fire-protection had been abandoned, the bamboos established themselves in dense masses even where late burning had been carried out in order to destroy the seed. Here teak seedlings contemporaneous with young bamboo were not found surviving except on the edges of the flowered areas where the fire had not been so intense. The only successful teak saplings

[1] Ind. Forester, xxxiii (1907), p. 242.

[2] Notes on a Tour in Forests on the West Slopes of the Pegu Yoma, 1917.

found were those which had already been on the ground prior to the flowering. This indicates that advance growth must play a prominent part in operations for securing natural reproduction of teak at the time of flowering of the bamboo. Mr. Smales, therefore, advocates stimulating advance growth as much as possible, in view of an expected general flowering of *Bambusa polymorpha*, by cutting gaps in the bamboo cover round teak seed-bearers and elsewhere, and sowing teak seed in these gaps.

Fig. 292 shows a group of promising advance growth of teak in an area of flowered *Cephalostachyum pergracile*. The dead culms have fallen or been broken down and undergrowth has been cut. As the young teak is weak and crooked the intention is to burn the area and cut back the teak.

In Burma great stress is laid on the necessity for carrying out extensive operations for effecting the reproduction of teak when *Bambusa polymorpha* flowers gregariously, as it is expected to do before very long. This bamboo is certainly of paramount importance, but there are other important bamboos, notably *Cephalostachyum pergracile*, which have frequently flowered gregariously in different localities, although the flowering has too often been allowed to pass by without any special operations being carried out in order to take advantage of it and to gain experience of how to proceed in the event of a general flowering of *Bambusa polymorpha*.

Based on such experience as has been gained in the treatment of teak in bamboo-flowered areas, certain measures were prescribed in 1914 in anticipation of a general flowering of bamboo, and particularly of *Bambusa polymorpha*. These measures comprise the following: (1) collection and storage of large quantities of teak seed annually, utilizing it for plantations and other operations before it deteriorates, in the event of the flowering not taking place; (2) previous selection of suitable bamboo areas in which to conduct operations, (3) careful protection of flowered bamboo areas from fire until the end of the hot season, followed by burning before the rains commence, in order to destroy as much bamboo seed as possible, even if dibbling of teak seed cannot be carried out; (4) removal of low overhead cover as far as possible prior to burning, and girdling of all large trees other than teak at the same time as or as soon as possible after burning; (5) dibbling of teak seed immediately after burning, roughly 6 ft. by 6 ft., two seeds in each hole not more than 1 in. deep; dibbling to be confined as far as possible to well-drained and accessible ridges and spurs, and to a distance of two chains on either side of them, broad, flat, badly drained ridges being avoided; broadcast sowing to be tried only on flat ridges and gentle slopes; (6) in the first and subsequent years after dibbling, burning to be carried out, if required, early in the season, in order to destroy fallen culms; weeding to be carried out, twice in each of the first two years and once in the third year. The total cost of these weedings is estimated at Rs. 15 per acre.

These prescriptions appear to be suitable so far as they go except in one particular, in which they are open to criticism, that is in the proposal to confine dibblings to a distance of two chains on either side of ridges and spurs, By so doing the mistake made in respect of so many of the Burma plantations, namely in scattering operations and thus greatly increasing the cost of upkeep, will be repeated. Again, the richest areas, where teak reaches its finest

development, are not the tops of the ridges but the well-drained fertile lower slopes, and it is here in particular that the stock of teak should be increased. The prescription might well be altered to include the sowing up of compact and not straggling or scattered areas, comprising not only the ridges and spurs but also the lower slopes and well-drained valleys. The areas operated over will be nothing more or less than plantations; they will in a short space of time be indistinguishable from *taungya* plantations, and will require to be tended in exactly the same manner. Indeed the regeneration of bamboo-flowered areas by the system of *taungya* plantations pure and simple will probably prove more efficient and less costly than the measures described.

Some examples of teak sowings in flowered bamboo areas in Burma may be quoted. In these sowings it has always been found that their success decreases and their cost increases with each year's delay after the year of seeding of the bamboo. This is due mainly to the extra cost and difficulty of weeding and cleaning with every year's start given to the young bamboo, for weeding and cleaning in young bamboo areas may be a very heavy item.

In the Kônbilin reserve of the Tharrawaddy division, where *Cephalostachyum pergracile* flowered gregariously in 1887, operations for increasing the quantity of teak were continued for seven years after the flowering of the bamboo. These operations consisted in girdling or felling and burning the tree-growth, cutting and burning the dead bamboo and afterwards the young bamboo growth, and dibbling teak seed as in a *taungya* plantation. The total area operated over exceeded 300 acres. This work showed clearly the advantage of the earlier over the later plantations, both in cost and in degree of success. In the case of these sowings the weeding was found to be a much heavier item than in the case of *taungya* plantations, and the average cost per acre during the first ten years worked out at Rs. 33–6–0 for the flowered bamboo sowings as against Rs. 20 for *taungya* plantations in the same locality; thereafter the cost in either case has been much the same. A considerable area of these flowered bamboo sowings has proved to be highly successful culturally, resembling a well-stocked plantation with a dense underwood of bamboo, which gives the teak a healthy and natural appearance.

Another successful series of flowered bamboo plantations has been formed to the east of Nyanlè, in the Taungnyo reserve of the Zigôn division. *Dendrocalamus strictus* flowered in 1878–9. Operations were commenced in 1881, that is, two years later than was advisable, and further areas were taken in hand in 1882 and 1883, the total area operated over in the three years being about 750 acres. The work consisted in felling all trees and bamboos, thoroughly burning, and sowing teak seed as in a *taungya* plantation. This was followed by weeding for three successive years, with another weeding in the seventh year in the case of the 1881 sowings and the fifth year in the case of the later sowings. The cost per acre of the three years' sowings up to the fourth year of weeding was as follows:

(1) 1881 sowings: first 3 years, Rs. 8–14–0; weeding of 7th year, Rs. 0–11–3: Total, Rs. 9–9–3 per acre.

(2) 1882 sowings: first 3 years, Rs. 15–9–0; weeding of 5th year, Rs. 2–6–0: Total, Rs. 17–15–0 per acre.

(3) 1883 sowings: first 3 years, Rs. 17–3–0; weeding of 5th year, Rs. 1–8–2: Total, Rs. 18–11–2 per acre.

FIG. 292. Natural reproduction of teak in area where bamboo (*Cephalostachyum pergracile*) has flowered, Myitkyina, Upper Burma: undergrowth cut, but area not yet burnt, and young teak generally weak and crooked; burning and cutting back of teak will be carried out.

Fig. 293. Sowing of teak and cutch (*Acacia Catechu*) in flowered bamboo area, Bwet forest, Prome, Burma : cutch tree on left.

These sowings have proved a great success, and are now represented by large areas of well-grown teak poles.

In the same neighbourhood, and to the north of Nyanlè, where *Dendrocalamus strictus* flowered in 1893–4, teak seed was dibbled among the unburnt bamboos in June. This proved a failure owing to insufficient felling and burning.

These examples will serve to show that very successful plantations can be established in flowered bamboo areas, provided operations are commenced as soon after the seeding as possible, that all overhead cover is cleared and thoroughly burnt, and that regular weeding is carried out in the young crop. Among other successful works of this kind may be mentioned the sowings in the Bwet reserve, Prome, following on a flowering of *Dendrocalamus strictus* in 1876. These would probably have been even more successful had not a good many large trees remained unfelled on the area. Recent flowered bamboo sowings in Prome have been supplemented by the transplanting of teak seedlings; of these natural forest seedlings have been found more successful than nursery seedlings, and of the former plants one year old or more have proved superior to young seedlings of the first rains. A successful example of the use of transplants in stocking a flowered bamboo area may be quoted from Katha, Upper Burma:[1] 'In the Katha division *tin* bamboo (*Cephalostachyum pergracile*) flowered in 1905 in the northern part of the division. The area was burnt in the hot weather, which stimulated the growth of coppice-shoots from teak stems burnt back. As natural teak seedlings did not spring up, nurseries were made and seedlings planted out in the rains of 1906 and 1907. The area was cleaned from time to time, and there is now (1914) a fine crop of young teak on the ground which only needs an occasional cleaning. The area treated was about 500 acres. The cost of the operation was about Rs. 10 per acre.'

Fig. 293 shows a young crop of teak mixed with cutch raised by sowing in a flowered bamboo area in the Bwet reserve, Prome. A dense growth of young bamboo will be noticed springing up under the teak.

STATISTICAL. Under favourable conditions the rate of growth of teak in its earlier years is very rapid, a mean girth of 2 in. and a mean height of 6 ft. per annum for the first few years being not unusual in well situated and tended plantations. Later the growth becomes somewhat slower, though in plantations which have been formed in favourable localities and have been regularly tended a girth increment of 1 in. a year or more may be expected. It will be convenient to consider statistical information separately for plantations and natural forest.

1. *Plantations. Burma.* The most recent statistics of a more or less complete nature relating to the teak plantations of Burma are those compiled by Mr. F. A. Leete[2] from data collected up to 1909. These statistics were prepared from measurements made immediately after thinning in selected fully stocked sample plots in teak plantations of different ages in various localities. As Mr. Leete remarks, it is as yet too early to determine whether all plantations throughout the province should be grouped together in one set

[1] Forest Administration Report, Burma, 1913–14.

[2] Memorandum on Teak Plantations in Burma. For. Bull. new ser., No. 2, 1911.

of curves, or different standards should be fixed in different localities. Meanwhile he has grouped them all together, and has obtained the following results :

Tectona grandis : rate of growth and number of stems per acre in teak plantations in Burma (F. A. Leete, 1909).

Age.	Mean girth.	Mean height.	Number of stems per acre.
years.	ft. in.	ft.	
10	1 3	38	530
20	2 4	62	185
30	3 1	84	95
40	3 9	96	75

Note. (1) Suppressed stems are not included ; (2) original spacing 6 ft. by 6 ft. or 12 ft. by 3 ft. giving 1,210 plants per acre.

As compared with an estimate formed by Mr. P. J. Carter in 1896, Mr. Leete's figures show a faster rate of growth in girth and a smaller number of stems per acre.

Central Provinces. Measurements made in 1896 in the Sakata and Korai plantations in Seoni gave the following results : [1]

Tectona grandis : measurements in Sakata and Korai plantations, Seoni.

No.	Locality.	Approximate age.	Number of stems per acre.	Mean girth.	Mean height.	Volume per acre.
		years.		ft. in.	ft.	cub. ft.
1	Sakata	26	418	1 4	44	2,289
2	,,	26	707	1 0	30	1,409
3	Korai	18	696	0 10	28	866

In the Sakata plantations the trees were reported to be very dense and in need of thinning, hence the poor girth increment.

Madras. A small plantation of 1868 at Ramanapenta in West Kurnool, measured in 1911, at an age of 43 years, had a height of 60 ft. and a girth varying from 2 ft. 8½ in. to 3 ft. 6½ in. The waterfall plantation at Mount Stuart, South Coimbatore, measured at an age of 42 years, had a mean height of 68 ft. and a mean girth of 2 ft. 9 in.

In his recent working plan for the Nilambur teak plantations Mr. Bourne has given yield tables based on extensive measurements in those plantations, and containing outturn figures in considerable detail. The statement on p. 763 gives a summary of the more important figures contained in those tables.

Andamans. Measurements made in 1910 gave the following results :

Year of plantation.	Age.	Mean girth.
	years.	ft. in.
1890	20	2 8
1889	21	2 9
1887	23	2 9
1883	27	2 5

2. *Natural forest.* (a) *Girth and height increment. Burma.* The statements facing p. 764, compiled from measurements recorded in the various working

[1] Working Plan for the Korai Range Forests, F. Linnell, 1896.

Tectona grandis : yield table for one acre of pure high forest, Nilambur plantations.

Age. years.	Standing crop, after thinning. Number of stems.	Mean girth at $4\frac{1}{2}$ ft. in.	Mean height of dominant trees. ft.	Solid volume of stemwood. cub. ft.	Intermediate yields: solid volume of stemwood. Periodic. cub. ft.	Total to date. cub. ft.	Total yield: solid volume of stemwood. cub. ft.	Mean annual increment calculated on total yield: solid volume of stemwood. cub. ft.
				I. Quality.				
5	..	12·8	41	388	..	..	..	..
10	266	19·9	56	732	..	504	1,236	124
15	179	26·4	66	1,002	374	878	1,880	125
20	137	31·9	74	1,247	278	1,156	2,403	120
25	110	37·0	81	1,471	287	1,443	2,914	117
30	91	41·8	87	1,688	278	1,721	3,409	114
35	79	46·0	93	1,901	263	1,984	3,885	111
40	69	50·0	97	2,111	238	2,222	4,333	108
45	62	53·7	102	2,316	221	2,443	4,759	106
50	56	57·5	106	2,513	196	2,639	5,152	103
55	51	61·1	110	2,696	186	2,825	5,521	100
60	48	64·6	113	2,868	161	2,986	5,854	98
65	46	68·0	116	3,032	134	3,120	6,152	95
70	44	71·2	118	3,188	102	3,222	6,410	92
75	43	74·2	119	3,336	66	3,288	6,624	88
80	42	77·2	121	3,478	30	3,318	6,796	85
				II. Quality.				
5	..	10·3	30	268	..	..	..	..
10	322	16·0	44	511	..	312	823	82
15	222	21·1	54	714	249	561	1,275	85
20	169	25·6	62	907	201	762	1,669	83
25	137	29·9	69	1,083	202	964	2,047	82
30	114	33·9	75	1,252	195	1,159	2,411	80
35	97	37·7	80	1,416	187	1,346	2,762	79
40	84	41·2	84	1,575	172	1,518	3,093	77
45	75	44·5	88	1,730	155	1,673	3,403	76
50	68	47·6	91	1,877	139	1,812	3,689	74
55	63	50·4	94	2,014	129	1,941	3,955	72
60	60	52·9	96	2,142	104	2,045	4,187	70
65	58	55·2	99	2,264	88	2,133	4,397	68
70	57	57·3	100	2,379	64	2,197	4,576	65
75	56	59·3	102	2,488	39	2,236	4,724	63
80	55	61·2	103	2,591	18	2,254	4,845	61
				III. Quality.				
5	..	7·8	19	148	..	..	..	..
10	404	12·1	32	292	..	120	412	41
15	290	15·8	42	429	125	245	674	45
20	224	19·3	50	567	122	367	934	47
25	182	22·8	57	694	116	483	1,177	47
30	151	26·2	62	815	114	597	1,412	47
35	127	29·4	67	930	111	708	1,638	47
40	109	32·4	71	1,040	103	811	1,851	46
45	96	35·2	73	1,143	93	904	2,047	45
50	86	37·7	76	1,241	79	983	2,224	44
55	81	39·8	77	1,332	69	1,052	2,384	43
60	80	41·3	79	1,416	51	1,103	2,519	42
65	78	42·3	81	1,496	43	1,146	2,642	41
70	77	43·3	83	1,570	26	1,172	2,742	39
75	76	44·3	84	1,640	14	1,186	2,826	38
80	76	45·3	85	1,704	5	1,191	2,895	36

Note. Volumes are calculated by the quarter-girth-squared formula, in sections of 9 ft.

plans, shows the estimated rate of growth in girth in different localities. Except in the case of the Mawku working circle of the Upper Chindwin division, these figures do not include bark thickness, for which about 2 in. should be added to the girth in each case. Nor is any allowance made for the time required for a natural seedling to establish itself; this period is usually placed at ten years, though one working plan allows fifteen years. It has been considered best to reduce all the figures to the same level by omitting the period allowed for the seedling stage, which is at the best a very rough estimate, and probably varies under different conditions. In the earlier working plans, notably those of Zigôn and Tharrawaddy, Pressler's borer was largely employed to estimate the rate of growth, and the figures obtained are probably less reliable than in most of the other working plans, where the rate of growth has been estimated from ring-countings. It may be noted that the figures given refer to trees which have grown up under natural conditions without any tending, and the rate of growth is probably slower than might be expected in regularly tended natural crops. In Tharrawaddy and Zigôn the rapid growth in the alluvial plains forests as compared with the hill forests is noticeable. This is not the case in Insein, where the soil of the plains forests is not so well drained as that of the Tharrawaddy and Zigôn divisions, and consists in places of laterite.

Central Provinces. The following statement showing the rate of growth in girth over bark and in height has been compiled from measurements made in different localities in the Central Provinces between 1909 and 1914:

Tectona grandis: rate of growth in girth and height in natural forest, Central Provinces; measurements made from 1909 to 1914.

Age.	Melghat, well-grown trees in favourable localities.	Saugor. Garhakota working circle.	Saugor. Kerpani felling series.	Saugor. Kishen-garh felling series.	Saugor. Patri-kata felling series.	Saugor. Gourj-hamar felling series.	S. Chanda: Allapilli reserve. Bhimaran hill forests.		S. Chanda: Allapilli reserve. Bhimaran plains forests.		S. Chanda: Allapilli reserve. Mirkullu
	Girth.	Girth.	Girth.	Girth.	Girth.	Girth.	Girth.	Height.	Girth.	Height.	Girth.
years.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft.	ft. in.	ft.	ft. in.
10	0 8	..	0 7	0 6	0 5	..	..	..	..	..	..
20	1 4	0 11	1 1	0 11	1 0	1 1	..	..	..	..	..
30	2 0	1 5	1 8	1 5	1 8	1 9	1 3	44	..	..	1 2
40	2 9	1 11	2 3	1 10	..	2 3	2 2	53	3 0	69	1 11
50	3 7	2 5	2 6	..	..	..	2 8	60	3 8	73	2 0
60	..	..	..	..	..	..	3 1	65	4 1	75	3 5
70	..	..	..	..	..	..	3 5	69	4 5	77	3 10
80	..	..	..	..	..	..	3 9	73	4 8	78	4 1
90	..	..	..	..	..	..	4 1	76	4 11	79	4 4
100	..	..	..	..	..	..	4 4	79	5 1	80	4 7
110	..	..	..	..	..	..	4 7	81	5 3	81	4 10
120	..	..	..	..	..	..	4 10	83	5 5	81	5 1
130	..	..	..	..	..	..	5 1	85	5 7	82	5 4
140	..	..	..	..	..	..	5 4	86	5 9	82	5 7
150	..	..	..	..	..	..	5 6	87	5 11	83	5 9

Mr. J. W. Best[1] has recorded the following summary of measurements of over 4,000 felled teak trees, in two local quality classes, in the Hoshangabad forests:

[1] Ind. Forester, xliv (1918), p. 408.

Tectona grandis: rate of growth in girth in natural forest, Burma.

MEAN GIRTH.

	Upper Chindwin.		Myittha.		Lower Chindwin.	Bhamo.	Katha.	Ruby Mines.				Pyinmana.														Thayetmyo.	Prome.		
Age.	Mawku.	Ahlaw.	Kale.	Taungdwin.	Thingadon-Yama and Patolon.	Mosit.	Mohnyin.	Nanhan, Nampaw, and Subôk.	Maingtha, Kunchaung, and Nanme.	Hintha, Ondôk, and Kyauktaung.	Wapyudaung.	Sinthe.	Pozaungdaung. Dry.	Pozaungdaung. Moist.	Pozaungdaung. Av.	Taungnyo.	Ngalaik.	Yanaungmyin, Kaing, and Palwe.	Yonbin.	Minbyin. Dry.	Minbyin. Moist.	Minbyin. Av.	Yeni.	Ziyaing-Mehaw.	E. Yoma, Satsuwa, and Tindaw.	Shwele.	Nawin.	Age.
years.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	years.
30	1 8	..	..	..	1 7	..	..	..	..	..	1 6	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	30
40	2 3	1 7	..	..	2 2	..	2 8	..	..	..	2 1	..	..	..	..	..	..	2 7	..	..	..	..	..	..	..	..	..	40
50	2 10	2 1	2 6	2 11	2 10	..	3 4	2 10	2 11	..	2 7	..	..	..	..	2 8	2 9	3 1	2 8	..	..	..	3 0	..	3 0	..	..	50
60	3 5	2 7	3 0	3 5	3 7	..	4 0	3 3	3 5	2 10	3 1	2 9	2 8	2 11	2 10	3 2	3 4	3 7	3 1	..	3 1	2 10	3 7	..	3 6	2 10	3 0	60
70	3 11	3 1	3 6	3 11	4 4	..	4 8	3 8	3 11	3 3	3 7	3 2	3 1	3 6	3 4	3 9	3 10	4 1	3 5	2 8	3 8	3 4	4 2	3 2	3 11	3 4	3 6	70
80	4 4	3 7	4 0	4 5	5 1	4 1	5 2	4 1	4 4	3 7	4 1	3 7	3 6	4 1	3 9	4 3	4 4	4 6	3 9	3 1	4 2	3 10	4 9	3 6	4 4	3 10	4 0	80
90	4 9	4 0	4 5	4 10	5 9	4 7	5 7	4 6	4 9	3 11	4 7	4 0	3 10	4 7	4 2	4 9	4 10	4 11	4 1	3 6	4 7	4 4	5 4	3 10	4 9	4 4	4 6	90
100	5 1	4 5	4 10	5 3	6 4	5 1	5 11	4 10	5 2	4 3	5 0	4 5	4 2	5 1	4 7	5 3	5 3	5 4	4 6	3 11	5 0	4 10	5 10	4 2	5 2	4 10	4 11	100
110	5 5	4 10	5 3	5 8	6 10	5 7	6 3	5 2	5 7	4 7	5 5	4 9	4 6	5 6	5 0	5 9	5 8	5 9	5 0	4 4	5 5	5 3	6 3	4 6	5 7	5 4	5 4	110
120	5 9	5 3	5 8	6 0	7 4	6 0	6 7	5 6	5 11	4 11	5 10	5 1	4 10	5 11	5 4	6 2	6 0	6 2	5 6	4 9	5 10	5 8	6 7	4 10	6 0	5 10	5 8	120
130	6 1	5 8	6 1	6 4	7 9	6 5	6 11	5 10	6 3	5 3	6 2	5 5	5 2	6 3	5 8	6 7	6 4	6 7	6 0	5 1	6 3	6 0	6 10	5 2	6 5	6 3	6 0	130
140	6 5	6 1	6 5	6 8	..	6 10	7 2	6 1	6 7	5 7	6 6	5 9	5 5	6 7	6 0	7 0	6 8	7 0	6 6	5 5	6 8	6 5	7 1	5 6	6 10	6 8	6 4	140
150	6 8	6 5	6 9	7 0	..	7 3	7 5	6 4	6 11	5 11	6 10	6 1	5 8	6 11	6 4	..	7 0	..	7 0	5 9	7 1	6 9	..	5 10	7 2	7 1	6 8	150
160	6 11	6 9	7 1	..	..	7 7	7 8	6 7	7 2	6 3	7 2	6 5	5 11	7 2	6 8	..	..	..	..	6 1	..	7 1	..	6 2	..	..	7 0	160
170	7 1	7 1	..	..	..	7 11	7 11	6 10	..	6 7	7 6	6 9	6 1	..	6 11	..	..	..	..	6 5	..	..	..	6 6	..	..	..	170
180	..	..	..	..	..	8 2	8 2	7 1	..	6 10	7 10	7 1	..	..	7 2	..	..	..	..	6 9	..	..	..	6 9	..	..	..	180
190	..	..	..	..	..	..	8 5	..	..	7 1	8 1	..	..	..	..	..	..	..	..	7 1	..	..	..	7 0	..	..	..	190
200	..	..	..	..	..	..	8 8	..	..	..	8 4	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	200
210	..	..	..	..	..	..	8 11	..	..	..	8 7	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	210
220	..	..	..	..	..	..	9 1	..	..	..	8 10	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	220
230	..	..	..	..	..	..	9 3	..	..	..	9 1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	230
240	..	..	..	..	..	..	9 5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	240
250	..	..	..	..	..	..	9 7	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	250
260	..	..	..	..	..	..	9 9	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	260
270	..	..	..	..	..	..	9 11	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	270
280	..	..	..	..	..	..	10 1	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	280
290	..	..	..	..	..	..	10 3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	290
300	..	..	..	..	..	..	10 5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	300
Rotation (years)	180	180	180	180	..	180	180	180	165	180	..	160	173	..	..	150	150	150	180	..	..	180	150	200	160	150	150	Rotation (years)
Exploitable girth	7 ft.	7 ft.	7 ft.	7½ ft.	7½ ft.	8 ft.	8 ft.	7 ft.	7 ft.	7 ft.	8 ft. / 7½ ft.[1] / 6 ft.[2]	6 ft.	7 ft. / 6 ft.[2]	..	..	7 ft.	7 ft.	7 ft.	7 ft. / 6 ft.[2]	..	..	7 ft. / 6 ft.[2]	7 ft.	7 ft.	7 ft. / 6 ft.[2]	7 ft. / 6 ft.[2]	7 ft. / 6 ft.[2]	Exploitable girth

[1] Second quality forest.

[2] Dry or poor forest.

Tectona grandis: rate of growth of natural teak, Hoshangabad, Central Provinces.

Age.	Local quality I (i. e. trees attaining a height of over 50 ft. in 40 years). Mean height.	Mean girth at 4½ ft. from ground.	Local quality II (i. e. trees attaining a height up to 50 ft. in 40 years). Mean height.	Mean girth at 4½ ft. from ground.
years.	ft.	in.	ft.	in.
5	14	7	11	3
10	21	13	18	6
15	27	17	22	9
20	33	21	26	11
25	38	25	29	15
30	43	30	32	17
35	47	33	34	20
40	50	37	36	22
45	53	40	38	25
50	56	45	40	27
55	58	47	42	30
60	60	50	44	32
65	62	52	45	34
70	62	54	47	35
75	62	55	48	37
80	62	56	48	38
85	62	56	49	39
90	62	56	49	39
95	62	56	..	..
100	62	56	..	..

Bombay. The statement on p. 766 which shows the average rate of growth in girth, has been compiled from measurements recorded in Bombay working plans. In each case bark thickness has been included; where this has not been definitely given in the working plans it has been taken to be 0·25 in.

(b) *Taper of logs*. Mr. H. F. Blanford[1] has worked out, from numerous measurements in the Mohnyin and Mosit forests, Upper Burma, the taper of bottom logs 25 ft. in length, with the view of arriving at an estimate of the minimum girth of trees to be felled in order to produce 'Europe squares', that is, sound, straight timber, free from sapwood, at least 12 in. square and 18 ft. in length, and averaging not less than 25 ft. in length. These measurements show that the taper increases slightly with age. Allowing for sapwood and bark, the minimum girth at the thin end of the log, in order to produce these squares, is 6 ft. The measurements of taper show that a breast-height girth of 7 ft. 9·7 in., or in round figures 8 ft., is necessary to produce a girth of 6 ft. at 25 ft. above the felling wedge, that is, to produce an average 'Europe square'. Mr. Blanford's measurements are summarized as follows:

Girth at breast height.	Average taper, i. e. diminution in girth to a height of 25 ft. above felling wedge, or 27 ft. 6 in. from ground. Mohnyin.	Mosit.
	in.	in.
6 ft. to 6 ft. 11 in.	16·1	14·1
7 ft. to 7 ft. 11 in.	19·7	14·4
8 ft. to 8 ft. 11 in.	23·4	15·7
9 ft. to 9 ft. 11 in.	26·0	19·1

Example: in Mohnyin a tree with a breast-height girth of 8 ft. has a girth at 25 ft. above the felling wedge of 8 ft. − 23·4 in. = 6 ft. 0·6 in.

[1] (1) Working Plan for the Mohnyin Reserve, Katha, 1910–11 to 1929–30.
(2) Mosit Working Plan, Bhamo, 1910–11 to 1939–40.

Tectona grandis: rate of growth in girth in natural forest, Bombay.

Mean girth.

Age.	Thana.	Panch Mahals.	Khandesh.		Nasik.	Poona.		Satara.	Kanara.						Belgaum.		Dharwar.
	Talasari and Mokhada range.	Dohed and Jhalod.	Taloda and W. Shahada.	Shirpur and Shahada East Satpudas.	Below Ghat forests.	Igatpuri and Sinnar range.	Poona teak forests (coppice).	Karad, Patan, and Shirala teak forests (partly coppice).	Bhagwati blocks VIII, IX, and XX.	Mundgod teak pole forests (all blocks combined).	Mundgod high forest blocks XXII and XXIII.	Kalinaddi Slopes.	Sopinhosalli high forest.	Gund working circle.	Golihalli-Godoli.	Nagargali.	Dharwar range.
years.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
10	0 7	0 9	0 6	..	..	..	0 6	0 9	0 9	0 9	0 6	0 7	0 7	0 9	0 11	0 10	1 0
20	1 1	1 7	1 0	1 1	1 7	1 8	1 1	1 7	1 4	1 4	1 0	1 0	1 1	1 4	1 7	1 7	1 9
30	1 7	2 2	1 8	1 6	2 5	2 5	2 1	2 2	1 10	1 10	1 6	1 4	1 6	1 11	2 1	2 4	2 2
40	2 1	2 8	2 4	1 10	3 3	3 1	2 8	2 8	2 5	2 4	2 0	1 8	2 0	2 5	2 5	3 1	2 5
50	2 6	..	..	2 1	4 0	3 8	..	3 1	3 0	2 9	2 7	2 0	2 6	2 10	2 9	3 9	2 7
60	2 10	..	..	2 4	4 6	4 3	..	..	3 7	3 1	3 2	2 3	2 11	3 3	..	4 5	2 8
70	3 2	..	..	2 7	4 11	4 8	..	..	4 1	3 4	3 8	2 7	3 5	3 8	..	5 1	2 9
80	3 6	..	..	2 10	5 4	5 1	..	..	4 5	3 6	4 2	2 11	3 10	4 0	..	5 9	2 10
90	3 10	..	..	3 0	5 8	..	..	..	4 8	..	4 7	3 2	4 3	4 4	..	6 4	2 11
100	4 2	..	..	3 2	6 0	..	..		4 11	..	5 0	3 6	4 9	4 8	..	6 10	..
110	4 6	..	..	3 4	..	..	..	..	5 2	..	5 5	3 10	5 2	5 0	..	7 3	..
120	4 10	..	..	..	..	..	..	..	5 4	..	5 10	4 3	5 6	5 4	..	..	..
130	..	..	..	..	..	..	..	..	5 6	..	6 2	4 8	..	5 7	..	..	..
140	..	..	..	..	..	..	..	..	5 8	..	..	5 1	..	5 10	..	..	..
150	..	..	..	..	..	..	..	..	5 10	..	..	5 5	..	6 1	..	..	..
160	..	..	..	..	..	..	..	..	6 0	..	..	5 7	..	6 4	..	..	..
170	..	..	..	..	..	..	..	..	6 1	..	..	5 9	..	..	..	..	..
180	..	..	..	..	..	..	..	..	6 2	..	..	5 11	..	..	..	..	..
190	..	..	..	..	..	..	..	..	6 3	..	..	6 0	..	..	..	..	..
200	..	..	..	..	..	..	..	..	6 4	..	..	6 1	..	..	..	..	..

(c) *Volume figures. Burma.* The average volume of marketable timber in trees of different girths and ages in the Mohnyin and Mosit working circles has been estimated by Mr. Blanford as follows :

Tectona grandis : outturn of marketable timber from trees of different sizes, Mohnyin and Mosit.

Girth at breast height.	Mohnyin. Corresponding age.	Mohnyin. Average volume excluding bark.	Mosit. Corresponding age.	Mosit. Average volume excluding bark.
ft.	years.	cub. ft.	years.	cub. ft.
3	55	26	..	..
4½	77	37	..	..
6	112	54	129	62
7	144	77	155	97
7½	161	97	168	111
8	188	110	185	122
9	227	148	221	154
10	285	182	..	211
10½	314	198	..	232

Note. Ten years have been added to the age in each case, to allow for the time required for a seedling to establish itself.

The latest Tharrawaddy working plan for the Pegu Yoma forests gives the following outturn figures for dry and moist forest combined :

Tectona grandis : outturn figures, Tharrawaddy.

Girth class.	Volume of timber per tree.	Girth class.	Volume of timber per tree.
	cub. ft.		cub. ft.
6 ft. 6 in.–6 ft. 11 in.	74	8 ft. 6 in.–8 ft. 11 in.	147
7 ft. 0 in.–7 ft. 5 in.	88	9 ft. 0 in.–9 ft. 5 in.	166
7 ft. 6 in.–7 ft. 11 in.	104	9 ft. 6 in.–9 ft. 11 in.	186
8 ft. 0 in.–8 ft. 5 in.	136	..	..

The size of logs actually brought out from the forests must of necessity depend greatly on facilities for extracting large timber, apart from the size of the trees felled. The largest average logs brought out so far in any one sub-period under working plans prescriptions are the 639 logs extracted from the Kangyi reserve of the Zigôn forest division during the sub-period 1902–3 to 1905–6, which averaged 103 cubic ft. The following statement gives the names of forests from which the largest average logs were extracted up to 1910, the averages being given by single sub-periods :

Tectona grandis: volumes of average logs extracted during single sub-periods from forests in Burma up to 1910.

Forest division.	Working circle.	Average volume of all logs extracted during single sub-periods.	Forest division.	Working circle.	Average volume of all logs extracted during single sub-periods.
		cub. ft.			cub. ft.
Zigôn	Kangyi	103	Prome	N. Nawin	67
,,	Taungnyo	92	,,	S. Nawin	67
,,	,,	90	Zigôn	Bawbin	67
,,	Kangyi	79	Tharrawaddy	Thonzè	67
,,	Bawbin	73	S. Toungoo	Kabaung	67
,,	Gamôn	72	,,	,,	66
Tharrawaddy	Kadinbilin	72	Tharrawaddy	Minhla	66
Prome	Shwele	68	,,	Môkka	66
N. Toungoo	W. Swa, Sabyin, and Lonyan	68	Katha	Mohnyin	65

Note. Volume does not include bark.

Central Provinces. The following statement has been compiled from the results of measurements of 642 trees in the Allapilli forests, South Chanda :

Tectona grandis : outturn of average trees, Allapilli.

Girth at breast height.	Average volume per tree, round timber measured over bark.	Girth at breast height.	Average volume per tree, round timber measured over bark.
ft. in.	cub. ft.	ft. in.	cub. ft.
6 0	63	8 0	108
6 6	73	8 6	119
7 0	84	9 0	129
7 6	96	9 6	138

Bombay. The following is the result of a stem analysis of five teak trees made by Mr. W. A. Miller in the Kirwatti forests of Kanara :

Tectona grandis: stem analysis of five trees, Kirwatti forests, Kanara.

Age.	Mean diameter at breast height.	Mean height.	Mean volume.	Mean annual volume increment.
years.	in.	ft.	cub. ft.	cub. ft.
10	3·0	19	..	..
20	5·5	37	..	..
30	8·7	47	6·5	2·17
40	11·8	51	13·0	4·33
50	13·7	54	24·5	4·90
60	16·0	58	34·5	5·75
70	17·5	62	41·5	5·93
80	18·2	65	47·0	5·87
90	18·8	67	51·0	5·67
100	19·1	69	55·0	5·50

Mr. Miller has also recorded the following results of measurements in the forests of the Arbail Slopes, Kanara, showing the average growth of single trees : [1]

Tectona grandis : growth and outturn of single trees, Arbail Slopes, Kanara.

Age.	Mean diameter.	Corresponding girth.	Mean height.	Mean volume per tree.
years.	in.	ft. in.	ft.	cub. ft.
20	5·4	1 5	44	4
40	9·2	2 5	64	10
60	12·8	3 4	75	21
80	15·6	4 1	83	46
100	18·0	4 9	90	71
120	20·0	5 3	95	89
140	21·8	5 9	100	104
160	23·4	6 1	104	118
180	24·6	6 5	107	132
200	25·2	6 7	109	144
220	..	..	110	156
240	..	..	110	..

2. **Tectona Hamiltoniana,** Wall. Vern. *Dahat*, Burm.

A moderate-sized deciduous tree with 6- to 8-angled branchlets and leaves usually in whorls of three, sometimes opposite or in whorls of four, somewhat resembling teak leaves but much smaller. Wood brown, harder and heavier than teak, of good quality, but used mainly for fuel, though sometimes for house-posts. This is a common tree in the dry zone of Burma, in localities

[1] Working Plan for the Arbail Slopes, Central Division, Kanara, 1918.

where the rainfall varies from 23 to 45 inches. It is capable of growing on poor stony soil, and is often associated with *Terminalia Oliveri*, *Acacia Catechu*, *A. leucophloea*, *Diospyros burmanica*, and other species of the dry open scrub forests of Burma. The tree is leafless for a time during the hot season. The dense tomentose corymbose panicles of small pale blue or whitish flowers appear from June to August, and the fruits ripen in the following cold or hot season; the fruit is a small nut tightly enclosed in the persistent tomentose calyx. The tree is a light-demander, coppices well, and is drought resistant. Frost does not occur in its habitat.

2. GMELINA, Linn.

Gmelina arborea, Linn. Vern. *Gumhar*, *sewan*, Hind.; *Gomari*, Ass.; *Shivan*, Mar.; *Shivani*, Kan.; *Gumadi*, Tam.; *Yemane*, Burm.

A moderate-sized to large deciduous tree with opposite, broadly ovate, acuminate, usually cordate leaves, glaucous beneath, or stellately hairy or tomentose beneath in one variety. Bark light grey, smooth, corky, inside yellow, rapidly turning brown on exposure, exfoliating in patches when old and exposing smooth paler coloured bark beneath. Wood yellowish or greyish white, even-grained, soft, light, and strong, seasons well without warping and cracking, and is very useful for planking, panelling, carriages, furniture, boxes, and carpentry of all kinds. It has been pronounced very good for match manufacture. In view of the good quality of its wood and of its rapid growth the tree is well worth more attention for plantation purposes. Under the most favourable conditions it attains a height of 100 ft. or more and a girth of 15 ft.

Distribution and habitat. The tree is distributed generally throughout the greater part of India and Burma, but is usually scattered; it is commoner in Burma than elsewhere. It is found in the moist region of Ceylon. It reaches its largest dimensions in the mixed forests of moist regions, as in Burma, the eastern sub-Himalayan tract, Assam, and elsewhere, but extends into comparatively dry regions, as in Central India. Although usually found in mixed deciduous forest, it is occasionally found in evergreen forest, and is not uncommon in sal forest. In the western Himalaya it ascends the outer hills and valleys to 4,000 ft., where it may occasionally be seen in stunted form even in somewhat dry situations. Its choice of locality is wide, but it shows a preference for moist fertile valleys; it does not thrive where the drainage is bad, while on dry sandy or otherwise poor soil it remains stunted, and is apt to assume little more than a shrubby form owing to its being repeatedly killed back by drought.

In its natural habitat the absolute maximum shade temperature varies from under 100° to 118° F., the absolute minimum from 30° to over 60° F., and the normal rainfall from 30 to 180 in. or more.

Leaf-shedding, flowering, and fruiting. The leaves fall as a rule about January–February, the new leaves appearing in March–April. The panicles of flowers appear from February to April, when the tree is more or less leafless, or with the young leaves, and the irregular tubular corollas, about 1 in. long, dull chestnut, with a yellow lip and throat, quickly fall from the trees and cover the ground in their neighbourhood. The fruits ripen from

the end of April (Burma) to July. The fruit is a succulent ovoid or oblong drupe, 0·9–1·2 in. long, yellow when ripe, with a leathery shining pericarp, a sweetish pulp, and a hard bony stone. The stone (Fig. 294, *a*) is 0·6–0·9 in. long, ovoid, pointed at one end, usually 2-celled and 2-seeded, but sometimes 1- or 3-celled and seeded. About 40 stones average 1 oz. in weight. Seed-year records in Chittagong and in the Santal Parganas show that the tree seeds well as a rule every year. The germinative power of fresh seed is high, but if stored for a year a considerable proportion of the seed loses its vitality: a sample of fruit-stones tested at Dehra Dun, which gave 90 per cent. of success when fresh, gave only 30 per cent. when kept for one year. The highest percentage obtained from fresh fruit-stones was 112, often two and sometimes three seedlings emerging from one stone. The fruits are eagerly devoured by cattle and deer, and the stones are spread by their agency.

Germination (Fig. 294, *b–f*). Epigeous, resembling that of the teak. The stone of the drupe opens by means of one or two lateral valves, the radicle emerging first and the cotyledons issuing shortly after. The stone is either left on or in the ground, or is carried up over the cotyledons, falling with their expansion.

The seedling (Fig. 294).

Roots: primary root long, at first thin, afterwards thickening considerably, terete, tapering: lateral roots moderate in number and length, fibrous, distributed down main root or more plentiful in its upper part. *Hypocotyl* distinct from and thicker than root, 0·3–0·7 in. long, terete or obscurely quadrangular, white turning green, finely pubescent. *Cotyledons*: petiole 0·1–0·2 in. long, channelled or flattened above, finely pubescent with capitate hairs: lamina 0·5–0·7 in. by 0·3–0·4 in., elliptical or ovate, emarginate, entire, somewhat fleshy, yellow turning green, finely pubescent with capitate hairs, midrib deeply impressed on upper surface, lateral veins less distinct. *Stem* erect, more or less quadrangular near the nodes, green, finely pubescent with capitate hairs; internodes 0·5–3 in. long. *Leaves* simple, opposite, exstipulate. Petiole 0·3–1·5 in. long, channelled above, green, glabrous or finely tomentose. Lamina 1·5–3 in. by 1·2–3 in., broadly ovate, acute or acuminate, widely dentate or sinuate, base cordate, cuneate, or obtuse, with glands near the petiole, green above, glaucous beneath, glabrous or lower surface glabrescent or finely pubescent with capitate hairs on the principal veins; lateral veins 3–5 pairs, including two prominent basal lateral veins.

Under favourable conditions the growth of the seedling is rapid, more particularly from the second year onwards. Although able to struggle against weeds more successfully than many other species, it responds to weeding by more rapid growth and increased vigour; it also benefits by irrigation. On stiff soil its development is poor. Among damp weeds the seedlings are apt to rot during the rain.

The season's growth ceases about November, the leaves fall in December–January, and the new leaves begin to appear in February–March (northern India). From May onwards in the second season the growth is rapid. The axillary buds of the stem usually commence to sprout in the first season, and in vigorous plants side branches may reach several inches in length; in the second year strong side branches are developed.

The seedling is fairly hardy as regards drought and frost. In frosty localities the leaves are often touched, the shoots escaping, but in grass the

FIG. 294. *Gmelina arborea*—SEEDLING × $\frac{5}{8}$

a—Stone of fruit b-f—Germination stages g, h—Development of seedling during first season

seedlings may be entirely killed down, though their power of recovery from the base is good. Seedlings are somewhat light-demanding, their development being poor under shade which is at all heavy. In the germinating stages crickets are often destructive, while in the sapling stage much damage is done by a boring insect which tunnels down the shoots and frequently kills the leading ones ; the attack may be recognized by holes in the side of the shoot affected.

The following measurements in experimental plots at Dehra Dun give some indication of the rate of growth of young plants under different conditions :

Gmelina arborea : development of seedlings under different conditions, Dehra Dun.

	Condition under which grown (in sunny locality in each case: shade experiments failed).	Height at end of season, and other particulars. 1st season.	2nd season.	3rd season.	4th season.
	(1) Natural conditions (fruits scattered on bare ground, uncovered)	0 ft. 7⅛ in.	4 ft. 0 in. (only one seedling germinated)	10 ft. 0 in.	..
	(2) Natural conditions (fruits scattered on bare ground, uncovered)	Maximum 0 ft. 11 in.	..	..	..
	(3) Natural conditions (fruits scattered on grassy ground)	Maximum 0 ft. 10½ in.	..	..	..
	(4) Nursery plants	Maximum 1 ft. 3 in.	..	..	..
	(5) Transplants of 1st season, entire roots and stem (unweeded after transplanting)	Maximum 1 ft. 4½ in.	Maximum 3 ft. 9 in.	0 ft. 9 in.–5 ft. 3 in.	13 ft.–14 ft. (maximum girth 9 in. at 3½ ft. from ground)
	(6) Transplants of 1st season, entire roots and stem (unweeded after transplanting)	Maximum 1 ft. 8 in.	11 in.–5 ft. 3 in.	2 ft. 8 in.–9 ft. 6 in.	..
	(7) Transplants of 2nd season, pruned stem and root	..	..	2 ft. 5 in.–3 ft. 1 in.	..
Adjacent.	(8) Broadcast sowings, irrigated, weeded	Maximum 2 ft. 10 in. (vigorous)	2 ft. 8 in.–10 ft. 0 in. (vigorous, 33 survivors)	..	..
	(9) Broadcast sowings, irrigated, unweeded	Maximum 0 ft. 5½ in. (weakly)	1 ft. 1 in. (only one survivor)	..	..
	(10) Broadcast sowings, unirrigated, weeded	Maximum 0 ft. 10 in.	1 ft. 11 in.–5 ft. 4 in.	..	..
	(11) Broadcast sowings, unirrigated, unweeded	Maximum 0 ft. 9 in.	1 ft. 6 in.–4 ft. 0 in.	..	..
Adjacent.	(12) Line sowings, irrigated, weeded, thinned	Maximum 3 ft. 3½ in.	5 ft. 10 in.–8 ft. 9 in.	14 ft. 0 in.–17 ft. 10 in.	..
	(13) Line sowings, irrigated, weeded, unthinned	Maximum 4 ft. 4 in.	3 ft. 0 in.–12 ft. 2 in.	8 ft. 0 in.–17 ft. 8 in. (stems less vigorous than in thinned lines)	..
	(14) Line sowings, irrigated, unweeded, unthinned	Maximum 3 ft. 0 in.	4 ft. 7 in.–10 ft. 3 in.	8 ft. 0 in.–16 ft. 5 in. (stems thin and lanky)	..
	(15) Line sowings, unirrigated, weeded, thinned.	Maximum 4 ft. 6 in.	Maximum 10 ft. 6 in.	..	..
	(16) Line sowings, unirrigated, weeded, unthinned	Maximum 3 ft. 3 in.	Maximum 7 ft. 0 in.	..	..
	(17) Line sowings, unirrigated, unweeded, unthinned	Maximum 3 ft. 8 in.	0 ft. 10 in.–7 ft. 0 in.	..	..
	(18) Line sowings, weeded, in combination with field crops (suppressed by crops in first season)	0 ft. 2 in.–0 ft. 10 in.	Maximum 6 ft. 4 in.	..	..

Some of these measurements indicate the value of weeding.

SILVICULTURAL CHARACTERS. The tree is a light-demander, though it stands rather more shade than the teak. It is moderately frost-hardy, and has good power of recovery when injured by frost. It does not stand excessive drought, as is shown in the case of plantations in the Panch Mahals, Bombay, on dry soil with a considerable proportion of sand, where the trees have in many cases either died outright or have died back and kept alive only in stunted bushy form. In Lahore Cantonment, however, it grows without irrigation, which not many trees are capable of doing.

It coppices very well, the coppice-shoots growing vigorously. It has not been observed to produce root-suckers to any extent, but Mr. R. N. Parker mentions that they have been produced by a tree in the Changa Manga plantation. Saplings are readily browsed by deer, which do much damage in young plantations. Cattle also browse young plants if there is an insufficiency of other fodder.

NATURAL REPRODUCTION. Under natural conditions germination takes place in the rainy season soon after the fall of the fruits. If the fruits are eaten by deer or cattle the stones are rejected during rumination ; otherwise the fleshy portion soon either roots off, or is softened and washed off by rain, or is eaten away by insects, leaving the stone exposed. Numerous experiments have been carried out at Dehra Dun to ascertain the factors influencing natural reproduction, and the chief of these have been established with tolerable certainty. It is clear that, as in the case of teak, a considerable amount of alternating heat and moisture is necessary to stimulate germination, for which reason fruit-stones lying in shade which is at all heavy fail to germinate for want of the sun's heat. Secondly, it is of great importance that the stones should become buried to some extent, otherwise there is a strong risk of failure to germinate. This was confirmed many times, the seed on very rare occasions succeeding in germinating if lying on the surface of the ground ; want of sufficiently continuous moisture appears to be the explanation of this. In the few cases in which germination did take place under these conditions the young seedling was usually washed away by rain before it obtained a foothold. Thirdly, clear ground forms a favourable germinating bed, particularly if it has been broken up so that the seed has a chance of becoming buried ; seed lying among weeds or grass usually fails to germinate. In this connexion it may be noted that plentiful natural reproduction has been observed on abandoned *taungya* lands (temporary cultivation) in Burma.

In the forest natural reproduction is not as a rule plentiful, and as the germinative power of the seed is high the only explanation is that a combination of favourable conditions is not very frequent. Apart from the factors which favour germination, the establishment of reproduction depends on the admission of a considerable degree of light, while in grazed areas reproduction has little chance of making headway owing to the readiness with which the young plants are browsed.

ARTIFICIAL REPRODUCTION. The tree can be raised easily either by transplanting from the nursery or by direct sowings ; the latter have proved much more successful than the former at Dehra Dun. It is also said that large cuttings planted during the rainy season strike well ; this possibly applies to a damp climate or where irrigation is carried out, but cuttings tried at

FIG. 295. *Gmelina arborea*, irrigated line sowings 5 months old, maximum height 4 ft. 5 in., Dehra Dun.

FIG. 296. *Gmelina arborea*, irrigated line sowings, end of third season, height 14–18 ft., Dehra Dun.

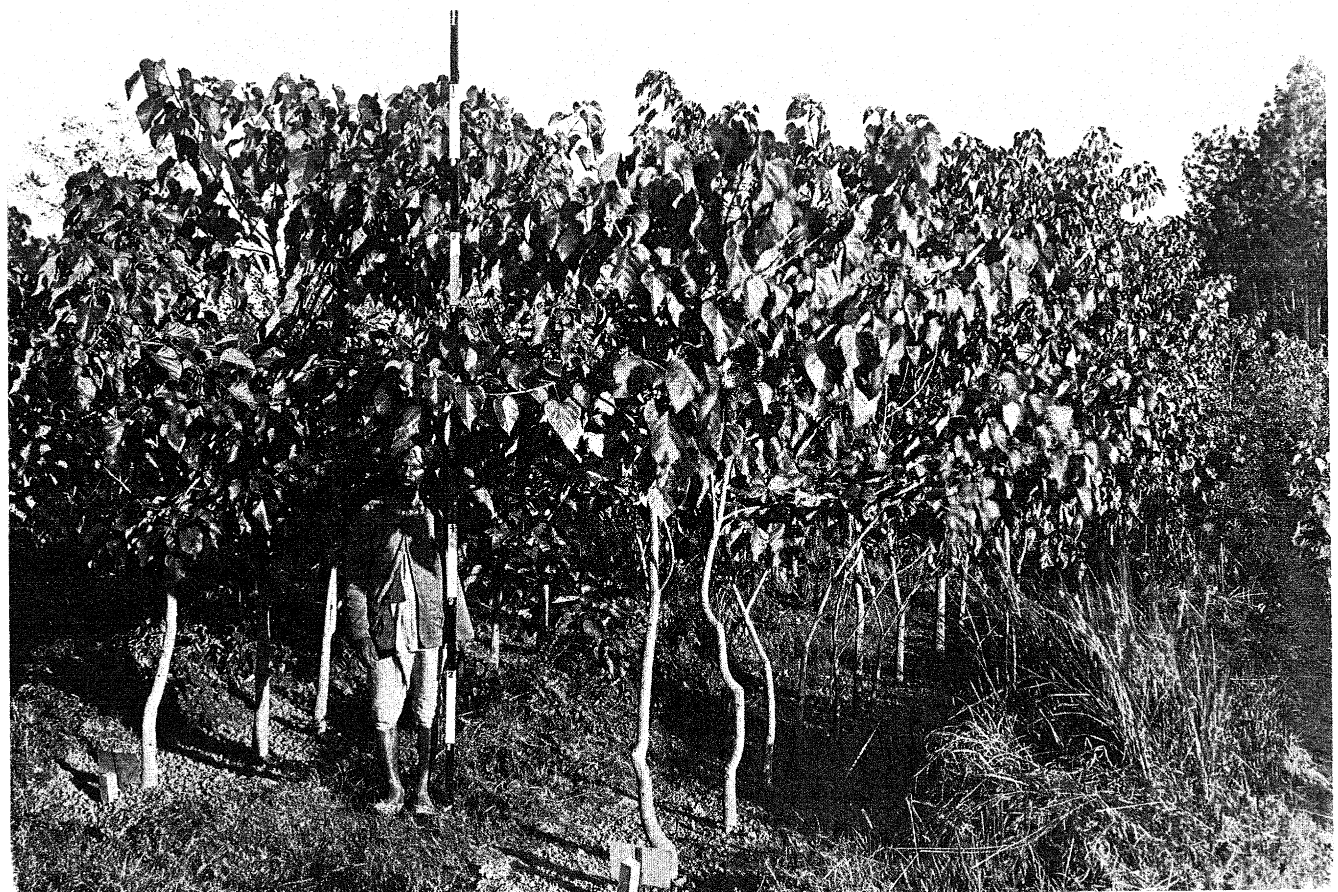

FIG. 297. *Gmelina arborea*, unirrigated weeded line sowings, end of third season, height 10 ft., Dehra Dun. Staff shows feet.

Dehra Dun, although they sprouted and remained alive for some time, died off in the dry season.

For transplanting purposes the fruit-stones should be sown in drills in the nursery as soon as the fruit ripens, as a rule shortly before the rainy season commences. No shading is necessary, but the beds should be regularly watered and weeded. The seedlings ordinarily begin to appear in about two to three weeks.

Transplanting may be carried out either in the first or in the second rainy season. In the former case small plants about 3 or 4 in. high should be used, the seedlings being separated and planted out during damp weather with roots and stems intact. If the plants are to be kept for a year in the nursery they should be separated and pricked out to about 9 in. apart in the first rains while still small. Next rainy season they should be planted out with the stem pruned down to about 2 in. from ground-level, and the root trimmed to a length of about 1 ft.; they stand this treatment well. Subsequently it may be necessary to prune off surplus shoots springing from the stumped plants. For plantation purposes a spacing of 6 ft. by 6 ft. is ordinarily suitable.

At Dehra Dun direct sowing in lines has proved much more successful than transplanting, and has given excellent results. Where irrigation is possible this stimulates growth, but unirrigated line sowings have also given very good results, always provided the lines are kept regularly weeded. Items (8) to (18) of the statement under 'seedling' on p. 771 give some idea of the growth under different methods of sowing, and Figs. 295, 296, and 297 show line sowings in different stages. A distance of 10 to 12 ft. between lines and an interval of about 1 ft. between fruit-stones will be found sufficient, and 1 lb. of fruit-stones may be allowed roughly for 600 ft. of line. The stones can be most conveniently sown along a shallow furrow or dibbled in with the aid of a pointed stick, and lightly covered with earth in either case. Irrigated line sowings are carried out in the manner described for irrigated sowings of *Dalbergia Sissoo* (Vol. I, p. 306). Of unirrigated line sowings the most satisfactory are those carried out with the aid of field crops, but care should be taken to leave a width of about 2 ft. along the lines unsown with cereals, the latter being sown in the intervening spaces. If the field crops are sown continuously over the area the seedlings suffer from suppression during the first season, and may even be killed off if the cover is dense. In experiments carried out at Dehra Dun the crop employed was the lesser millet (*Eleusine coracana*), which was sown in May, formed a dense crop 3 to 3½ ft. high, and was reaped in October; the lines of *Gmelina* were sown in June. In line sowings along with field crops it is preferable to allow cultivation for a second year, the cultivator keeping the lines weeded, as this saves expense and serves to keep the ground clear of weeds for a longer period than if cultivation is done for one year only; at the same time the longer cultivation is permitted the smaller the area which can be planted annually by a given number of cultivators, and this may be a matter of importance if the area to be planted is large and the number of cultivators is limited.

In sowings of any form certain supplementary operations are essential to success. Weeding is of great importance, and hence the advantage of sowing in regularly spaced lines. Weeding should commence during the first season,

and for the first year or two clean weeding with slight loosening of the soil stimulates growth where this is a matter of importance, as in dry localities; after the first year or two all that is necessary is to free the plants from overhead cover. During the first rainy season it is advisable to pull up duplicate seedlings and plant them to fill up gaps; the pulling up of the surplus seedlings may be done in the ensuing dry season, but it will then be impossible to utilize them for filling gaps. Thinnings to relieve congestion in the lines should commence about the third year if necessary, the strongest and best-shaped plants being retained and the weakly and badly shaped ones removed; this operation is responded to by better growth.

As regards the location of plantations, it cannot be emphasized too strongly that plantations of *Gmelina arborea* can never pay unless rapid growth and fairly large dimensions are ensured. Plantations of this species therefore should never be made except on fertile soil in a climate at least moderately damp. Poor dry or shallow soil as well as badly drained clayey ground should be carefully avoided, as the plants will always remain stunted. Plantations formed in the dry climate of the Panch Mahals in Bombay, on dry somewhat sandy soil, have proved a complete failure, the plants remaining stunted or dying out altogether. On fertile loam in a fairly moist climate, however, plantations of this species, if properly formed and carefully tended, should be a source of considerable profit, as the wood cannot fail to command a good sale if placed on the market in regular annual quantities.

Mr. C. G. E. Dawkins [1] has described some successful experiments in raising plantations of *Gmelina arborea* in the Katha district of Upper Burma. He notes that for transplanting purposes the seed should be sown in the nursery by the middle of May at the latest, and the seedlings should be transplanted when 9 in. to 1 ft. in height, those which have grown too large being discarded. For transplanting in the cold season the seed should be sown in the nursery in September, and the seedlings should be transplanted in the end of October or the beginning of November, only the strongest plants being used. The great advantage of planting during the cold season, which gave 90 per cent. of success, is that the growth of grass is less luxuriant than during the rainy season, and the seedlings have the advantage of a good start. A successful plantation was formed in 1916 on a flat area with a strong growth of grass. This area was cleared in February, burnt in April, planted 6 ft. by 6 ft. about the end of May, and weeded once the following rainy season; by November the plants were 4 to 5 ft. in height. Next rainy season the plantation was weeded once in July, after which no further weeding was found necessary, owing to the fact that the crowns had closed up and suppressed the grass. In 1918 the plantation was thinned heavily, and in January 1919 the remaining stems had an average girth of 11 in., the largest tree having a girth of 20 in. and a height of 36½ ft.; there was marked dying off of side branches. An experimental *taungya* plantation also proved highly successful, the field crop employed being hill rice; it was found advisable, however, to sow the *Gmelina* seeds late in order to prevent the rice from becoming suppressed.

These experiments included also direct sowing, good results being obtained both by dibbling and by broadcast sowing. Seed dibbled 6 ft. by 6 ft. in the

[1] Ind. Forester, xlv (1919), p. 505.

middle of May, four or five seeds at each peg, resulted in a strong growth of plants, some of which reached a height of 11 to 12 ft. by the end of the rainy season, forming a complete canopy. Experimental broadcast sowing carried out in 1919 gave remarkable results. An abandoned *taungya* of 1917 was cleared of weed-growth and rather incompletely burnt in April 1918; next month the débris was removed, the soil was lightly raked, and seed was sown broadcast, about 45 lbs. to the acre. This resulted in a thick pure crop of *Gmelina* seedlings which killed out the weeds, rendering weeding unnecessary; in places the crop was 8 to 9 ft. high by October. The total cost of establishing the plantation was only Rs. 3–8–0 per acre, which could probably be reduced by employing only half the quantity of seed, spacing roughly 3 ft. apart, and sowing three seeds at each stake.

These experiments included the mixing of *Gmelina* with teak, but the former always became dominant and suppressed the teak.

Silvicultural treatment. This species is well adapted for treatment as coppice, the growth of which is rapid. The uncertainty of natural reproduction renders it difficult to rely on any system of high forest producing regular yields of this timber except by the system of clear-felling with artificial reproduction. In this case it is probable that the best results will be attained by growing it in mixture with a shade-bearer of somewhat slower growth, to act partly as a protection to the soil and partly as a means of preventing unnecessary branching in the *Gmelina*, which is somewhat prone to form low side branches unless drawn up.

Rate of growth. The growth is fast. Gamble's specimens averaged 4 rings per inch of radius, giving a mean annual girth increment of 1·57 in. Gamble also mentions the following cross-sections in the Bengal museum: (1) 10 rings for a mean diameter of $10\frac{1}{2}$ in., or rather less than 2 rings per inch of radius, giving a mean annual girth increment of 3·3 in.; (2) 27 rings for a diameter of 14 in., or nearly 4 rings per inch of radius, giving a mean annual girth increment of 1·63 in. A cross-section from the United Provinces in the silvicultural museum at Dehra Dun showed 35 rings for a girth of 3 ft. 9 in., giving a mean annual girth increment of 1·3 in., or less than 5 rings per inch of radius.

A plantation in the Panch Mahals, Bombay, which had suffered much from drought, showed when six years old a maximum height and girth of 18 ft. and 12 in. respectively, which is very fair considering the unsuitable climate.

In the young experimental plantations of Dehra Dun, measurements of which have been given above under 'seedling', the growth on the whole is probably unsurpassed by that of any of the numerous other species experimented with. The measurements already quoted in respect of young plantations in Katha, Upper Burma, also show remarkable growth. In this locality Mr. Dawkins found that seven naturally grown trees produced a mean girth of $4\frac{1}{2}$ ft. in twenty-one years, and he estimated that tended plantations would attain a mean girth of 6 ft., with about 100 stems per acre, in thirty years. A natural seedling in the forest near Kotdwara, United Provinces, which had a height of 5 ft. in January 1913, was remeasured in November 1916 and found to have a height of 22 ft.

Coppice growth is also rapid. A stool in a coupe fourteen years old in the Gorakhpur district, United Provinces, had produced three coppice-shoots 42 ft. high and 3 ft., 2 ft. 3 in., and 1 ft. 8 in. in girth respectively, while dominant sal coppice shoots near it had a maximum height of 35 ft., and averaged 1 ft. 6 in. in girth. In the Koderma forest, Hazaribagh, Mr. Haines in 1916 measured a coppice-shoot eleven years old with a girth of 1 ft. 6 in., the maximum girth of sal coppice-shoots near it being 1 ft. 3 in.

3. VITEX, Linn.

A genus containing about 15 Indian species of trees or shrubs with opposite digitately 3- or 5-foliate leaves ; it includes some useful timber trees. Silviculturally this genus has as yet received little study.

Species 1. *V. Negundo*, Linn. ; 2. *V. altissima*, Linn. f. ; 3. *V. pubescens*, Vahl ; 4. *V. peduncularis*, Wall. ; 5. *V. Leucoxylon*, Linn. f. ; 6. *V. glabrata*, R. Br.

1. **Vitex Negundo,** Linn. Vern. *Shiwáli*, Hind. ; *Marwan*, Pb. ; *Nirgud*, Mar. ; *Nochi*, Tam. ; *Vavili*, Tel.

A deciduous shrub with 3- or 5-foliate leaves, very common, and often gregarious, throughout the greater part of India, extending into dry regions and ascending to 5,000 ft. in the outer Himalaya. Abundant in open waste places, and as a hedge plant along roads and between fields. It is a useful plant for afforestation work, producing root-suckers and growing readily from cuttings. It is not usually browsed. The twigs are used for wattle-work and rough basket-work. Growth, according to Gamble, 7 rings per inch of radius, giving a mean annual girth increment of 0·9 in.

2. **Vitex altissima,** Linn. f. Vern. *Bulgi*, *mairole*, Kan. ; *Mayilei*, Tam.

A large or very large tree with a dense crown, quadrangular branchlets, and 3-foliate, rarely 5-foliate leaves. Bark grey, scaly, yellow and fibrous inside. Wood greyish brown, hard, close-grained, much in demand for building, furniture, &c. The tree is an important one in western and southern India, and is common both in evergreen and in deciduous forests of the Western Ghats, as well as in open dry forest in parts of the Deccan and Travancore ; also in Ceylon. Flowers, April–May ; fruits, July–August. The fruit is a small purple drupe. The tree stands a moderate amount of shade, especially in youth ; it produces root-suckers. Growth, according to Gamble, 8 to 9 rings per inch of radius, giving a mean annual girth increment of 0·7 to 0·78 in.

3 **Vitex pubescens,** Vahl. Syn. *V. arborea*, Roxb. Vern. *Nemali adugu*, Tel. ; *Myladi*, Tam. ; *Kyetyo*, Burm.

A moderate-sized to large tree with quadrangular branchlets and 3- or 5-foliate leaves. Wood very hard and close-grained, durable and useful. Forests of southern India, extending north on the east side to Orissa ; Sylhet, Burma in upper mixed deciduous forests, Andamans. In southern India it is common chiefly along the banks of streams. Growth, according to Gamble, 8 to 10 rings per inch of radius, giving a mean annual girth increment of 0·63 to 0·78 in.

A tree referred to by Mr. A. Rodger [1] under the name of *kyungauknwè*

[1] Working Plan for the Tagaung Working Circle, Ruby Mines Division, 1912, pars. 14 and 15.

in the forests of the Ruby Mines district, Upper Burma, perhaps belongs to this species. He describes it as occurring on fertile slopes along with well-grown teak, *Xylia dolabriformis*, *Terminalia tomentosa*, *Pterocarpus macrocarpus*, *Anogeissus acuminata*, *Pentacme suavis*, and other species, as well as various bamboos; also in dry stunted forest on poor shallow soil with *Diospyros burmanica*, *Terminalia Oliveri*, and the species already mentioned, teak being very scarce and of small size and the chief bamboo being *Dendrocalamus strictus*.

Mr. G. R. Jeffery [1] refers to this tree in the same district in the following words: 'Allied to teak and possessing many of the properties of teak, durable, light (floating in fresh water), even-grained but rarely attains sufficient dimensions or number to be worth extracting. Has a decided demand in Mandalay, which would be much greater were a regular supply obtainable. The tree has the appearance of a very slow growth and reproduction does not seem good.'

4. **Vitex peduncularis,** Wall. Syn. *V. alata*, Roxb. Vern. *Boruna*, Beng.; *Osai*, Ass.; *Kyetyo*, *pazin-nyo*, Burm.

A moderate-sized to large tree with trifoliate leaves, the petioles being winged in young plants and coppice-shoots. Wood hard, close-grained, used for posts and beams, yokes, &c. A tree of the eastern sub-Himalayan tract, Assam, Chota Nagpur, Orissa, and the Circars; common in upper mixed and tropical forests in many parts of Burma. Haines says that in Chota Nagpur it occurs in Singhbhum and Gangpur, especially along streams, but also on northern rocky slopes, and that in Manbhum and Hazaribagh it is very common and attains large size on the northern slopes of Parasnath; also in Koderma, Palamau, and the Santal Parganas (frequent). Flowers, March–June; fruits, August–September. The fruit is a small drupe with a 3- or 4-celled stone. Growth, according to Gamble, 6 to 8 rings per inch of radius, giving a mean annual girth increment of 0·78 to 1·05 in.

5. **Vitex Leucoxylon,** Linn. f. Vern. *Songarbi*, Mar.; *Hole-lakki*, *senkani*, Kan.; *Lokki*, Tel.

A small or large deciduous tree with a short thick trunk and spreading crown. Bark smooth, light-grey. Wood light greyish brown or pinkish, durable. Indian Peninsula from the Chanda district southwards, chiefly along banks of streams, Kanara and the Konkan. Flowers, February–March; fruits, June (Bourdillon).

6. **Vitex glabrata,** R. Br. Syn. *V. Leucoxylon*, Kurz. Vern. *Goda*, Beng.; *Tauksha*, Burm.

A large deciduous tree with 5-foliate leaves. Bark smooth, white. Wood grey, moderately hard, close-grained, durable, of good quality, used for cart-wheels. Assam, Chittagong, Burma, Andamans; also in the Rajmahal hills, very local (Haines). This is a common and conspicuous tree in the upper mixed deciduous forests of Burma, and is also fairly common in certain types of lower mixed forest, preferring well-drained ground; it is a common companion of the teak. Flowers, April–June; fruits, June–July. The fruit is a drupe about 0·5 in. long. Growth, according to Gamble, averaging 6 rings per inch of radius, giving a mean annual girth increment of 1·05 in.

[1] Working Plan for the Hintha Working Circle, Ruby Mines Division, 1909, par. 13.

4. PREMNA, Linn.

This genus contains over 30 Indian species of trees, shrubs, and climbers, of which none is of any great importance and many are rare. Silviculturally the trees have not been studied in detail; they may yet become important as furnishing close-grained woods suitable for the manufacture of bobbins.

Species 1. *P. tomentosa*, Willd.; 2. *P. pyramidata*, Wall.; 3. *P. bengalensis*, Clarke; 4. *P. latifolia*, Roxb.

1. **Premna tomentosa,** Willd. Vern. *Narvu*, Tel.; *Podanganari*, Tam.

A moderate-sized deciduous tree with branchlets and leaves densely stellate-tomentose. Bark light greyish brown. Wood smooth, close-grained, suitable for turning and carving (Gamble). Central and southern India; common in the Deccan and in the drier parts of southern India. Flowers with the young leaves in March–April; fruits, June (Bourdillon). The fruits are small drupes arranged in terminal cymes. The tree is not readily browsed by goats.

2. **Premna pyramidata,** Wall. Syn. *P. tomentosa*, Kurz. Vern. *Kyunbo, kyunnalin*, Burm.

A moderate-sized deciduous tree with branchlets and under sides of leaves softly stellate-tomentose. Bark light greyish brown. Wood hard, close-grained, suitable for turning and carving. A tree common throughout Burma in dry and upper mixed deciduous forests. Growth, according to Gamble, 4 to 8 rings per inch of radius, giving a mean annual girth increment of 0·78 to 1·57 in.

3. **Premna bengalensis,** Clarke.

A small or moderate-sized tree, closely allied to *P. pyramidata*, and possibly not specifically distinct. Eastern sub-Himalayan tract, chiefly on river-banks, Assam. Growth, according to Gamble, 3 to 5 rings per inch of radius, giving a mean annual girth increment of 1·26 to 2·1 in.

4. **Premna latifolia,** Roxb. Syn. *P. viburnoides*, Wall.; *P. mucronata*, Roxb. Vern. *Bakár*, Hind.

A small deciduous tree with thin light grey bark. Sub-Himalayan tract, Indian Peninsula, and Burma, chiefly in rather dry mixed deciduous forest. In the western sub-Himalayan tract it is often found in the mixed forest which marks the transition stage between the riverain forest of *Acacia Catechu* and *Dalbergia Sissoo*, and the final stage of sal forest on the more elevated lands. In northern India the tree is leafless from February to April. The corymbose inflorescences appear from April to June, and the fruit, a small drupe, ripens in the cold season. The remains of the infructescences persist on the trees long after the fruits fall. A cross-section in the silvicultural museum at Dehra Dun showed 43 rings for a girth of 2 ft. 11 in., giving a mean annual girth increment of 0·81 in.

5. CALLICARPA, Linn.

This genus consists mainly of shrubs, and the only species of some little interest is the following:

Callicarpa arborea, Roxb.

A small or moderate-sized tree with the branchlets, under sides of leaves,

and inflorescences densely tomentose with soft stellate hairs. Wood moderately hard, even-grained, resembling that of *Gmelina* (Gamble). The tree is a familiar one in the eastern sub-Himalayan tract, where it springs up readily on burnt savannah lands when they first come under fire-protection ; being a strong light-demander it soon becomes ousted by other trees. In Burma it comes up frequently in deserted *taungya* lands. The corymbose cymes of small lilac or purple flowers appear from April to June, and the fruit, a small drupe, ripens from August to November or sometimes later. Growth, according to Gamble, 5 rings per inch of radius, giving a mean annual girth increment of 1·26 in.

6. AVICENNIA, Linn.

Avicennia officinalis, Linn. Syn. *A. tomentosa,* Wall. White mangrove. Vern. *Tiwar,* Mar. ; *Ipati,* Kan. ; *Baen,* Sundarbans ; *Madda,* Tel. ; *Thamè,* Burm.

A large evergreen shrub or small tree of the mangrove swamps along the coasts and tidal creeks of India and Burma. It is one of the commonest of the Indian mangrove swamp species, growing gregariously, and often forming an extensive bushy growth, conspicuous from its grey foliage, and when in flower from its bright yellow inflorescences. In the Sundarbans it occurs in the inland parts of the littoral forest, and is characteristic of *bhils,* or moist depressions. It is common along the coasts of both sides of the Indian Peninsula as well as of Chittagong, Arakan, and Burma. In the Sittang estuary it sometimes forms 60 to 70 per cent. of the stock, and reaches a height of 25–30 ft. with a girth of 2–3 ft.

The wood has a peculiar structure, consisting of alternate layers of pore-bearing tissue and loose large-celled tissue without pores. It is brittle, and is used only as fuel, but in some localities it is an important fuel species.

The panicled heads of yellow flowers appear from March to June, and the fruit ripens from August to October. The fruit is a compressed ovoid one-seeded capsule 1–1·5 in. long, dehiscing into two thick valves. The large fleshy cotyledons fill the fruit. The seeds germinate immediately they fall, or even on the tree. A thick densely hairy hypocotyl elongates, from the lower end of which a number of rootlets appear, the shoot being produced from its upper end.

The seeds are buoyant, and are thus able to spread by the agency of water ; about October the tidal creeks are often full of the large seeds floating on the surface of the water, and most of this seed will be found to be germinating. To collect the seed for artificial reproduction, the best method is to drag with a small net, and throw the seed into a canoe, partly filled with water, which should then proceed straight to where the seed is to be sown, the seed being sown without delay. In Madras it is usual to sow the seed broadcast, the best time being between new moon and full moon, when the tides are lowest ; the sowing is done when the tide has run out and there is no water on the ground, otherwise there is danger of the seed floating away.[1]

Under favourable conditions the tree regenerates freely from seed. The necessary conditions appear to be frequent flooding and absence of dense low

[1] Working Plan for the Corringa Reserved Forest, Godavari District, H. F. Wood, 1902.

cover, which the seedlings do not tolerate. Thus a lowering of the water-level results in a cessation of reproduction, while a dense growth of *Acanthus ilicifolius*, prevalent in some localities, tends to kill out the seedlings. The tree does not coppice well. Its lateral roots spread in all directions through the mud in which it grows, and send up a plentiful crop of pneumatophores: Mr. A. W. Lushington has observed that in the Kistna mangrove forests these ultimately develop leaves and become trees.[1] This has not been recorded in any other locality, but in view of the poor coppicing power of the species it is a question of importance which requires further investigation in different localities.

7. LANTANA, Linn.

This genus contains about 50 species of tropical or sub-tropical shrubs, chiefly American. The only indigenous Indian species is *L. indica*, Roxb. (Syn. *L. dubia*, Wall.), a pubescent unarmed shrub with light purple, yellow or white, almost scentless flowers, found throughout the greater part of India. The plant known in India as the lantana, which has spread with alarming results over extensive tracts of country, is *L. aculeata*, Linn., a species introduced from tropical America.

Lantana aculeata, Linn. Syn. *L. Camara*, Linn.

A shrub with recurved prickles on the stems and branches, leaves with a strong odour of black currants when crushed, and orange-coloured flowers. The fruits are small blackish drupes and are readily devoured by birds and by squirrels, rats, jackals, and other animals, and the seeds are spread far and wide by their agency. The flowers and fruits are produced in great abundance at most seasons of the year. The shrub forms a very dense impenetrable growth many feet high, the prickly branches interlacing and forming a close network, while under luxuriant conditions of growth the plant becomes scandent, climbing into the crowns of trees.

A native of tropical America, lantana is said to have been first introduced into India as an ornamental and hedge plant in the first half of last century. It has since spread over a large part of southern India and over some other portions of the Peninsula, notably Berar and parts of Bombay. More recently it has become invasive in certain parts of northern India, for instance in the *bhabar* tract round Haldwani in the United Provinces and in the outskirts of Dehra Dun. It has spread to a considerable extent in the neighbourhood of Shillong, and unless kept in check is likely to extend throughout the Khasi and Jaintia hills. It has also succeeded in gaining a foothold in some parts of Burma, and indeed wherever conditions are at all favourable to its growth it spreads with alarming rapidity, and areas which in one year may contain only a few bushes sparsely dotted about will often become covered with a dense impenetrable mass of lantana within the space of a few years. Grazing-grounds thus become ruined in a short space of time, since the dense growth not only prevents the access of cattle, but also kills out grass. The plant is not readily browsed by cattle; goats and camels occasionally nibble the very young leaves, but only when there is no other fodder at hand. Horses have been observed to eat it. The plant flourishes under varying climatic conditions,

[1] Inspection Notes, 1910.

from moist regions where the rainfall exceeds 200 in. to comparatively dry localities where it is as low as 30 in. It flourishes equally well on flat and on hilly ground, and on a variety of soils, including poor gravel and laterite. The plant is light-loving, but will grow under moderate shade. It is very tenacious of life, coppicing vigorously and producing root-suckers, which necessitates very thorough uprooting to prevent the reappearance of shoots. It regenerates freely from seed, and a severe fire or a succession of fires is necessary to prevent seedlings appearing in profusion. It burns readily, even when green, and after a fire it recovers rapidly, soon becoming as dense as ever.

Nowhere has the lantana become so troublesome as in the south-western portion of the Indian Peninsula, in Coorg, parts of Mysore, the Nilgiris, and elsewhere. In Coorg alone the estimated areas of different classes of land infested by lantana in 1912 were: private land, 70,400 acres, of which 35,000 acres had been cleared; Government waste land, 40,000 acres; reserved forests, 74,000 acres. An extensive scheme for eradicating lantana over an area of 63,200 acres in reserved forests and other Government lands in Coorg was drawn up in 1914, but owing to the outbreak of war in that year the scheme was held in abeyance. This scheme, extending over a period of eleven or twelve years, was estimated to cost Rs. 4,40,000. This figure indicates the magnitude of the task involved in dealing with the pest once it spreads, and the necessity for eradicating it as soon as it makes its appearance in any locality and before it gets out of control. So serious has the lantana question become in Coorg that it has led to the passing of a special enactment entitled *The Coorg Noxious Weeds Regulation, 1914.*

The eradication of lantana in Coorg has been the subject of detailed experiment by Mr. H. Tireman, who has published an interesting paper on the subject.[1] The most practicable method so far evolved is to burn the lantana about February or March, cut it about a foot above ground, roll the cut material away from the stumps and burn it, the stumps being then dug up at the commencement of the rainy season when the ground is soft; the lantana is shallow-rooted, and in many cases the stumps can be pulled up by hand in soft ground. Uprooting of the regrowth is necessary for two or sometimes three or four years after the first cutting. The average cost of the work is Rs. 7 to Rs. 8 per acre for the principal clearing, or where the lantana is exceptionally dense as much as Rs. 12 per acre. For uprooting the regrowth the cost varies from 12 annas to Rs. 1–8–0 per acre in the second year, and is about 6 annas in the third year, and slightly less in the fourth year.

In parts of Madras elephants have been trained to pull up lantana, the full-grown animals pulling the shrubs up by curling their trunks round them, and the younger ones pulling at a chain at the end of which is a hook fixed into the roots of the shrub; this operation, however, requires to be followed by a further eradication by hand, repeated at intervals. In practice the use of elephants is possible only on a limited scale.

The question of destroying lantana or preventing its spread by the aid of natural insect enemies, both indigenous and introduced, is under investigation, but the introduction of foreign insect enemies, such as the *Agromyza* fly, which destroys lantana seed in the Hawaiian Islands, is a measure requiring

[1] Ind. Forester, xlii (1916), p. 385.

to be carried out with great caution owing to the danger of the insect spreading to other host plants of valuable species.

Although the lantana is a serious pest under many conditions, it is not always to be regarded as devoid of good qualities of any kind. Outside forest tracts the principal charges against it are that unless kept in check, often at considerable cost, it quickly overruns and monopolizes waste lands, grazing-grounds, cultivated land left fallow for a short time, and coffee and other plantations, and owing to the high cost of eradicating it it is a serious check to the spread of cultivation; in the neighbourhood of cultivated or village lands it harbours pigs, which destroy the cultivators' crops, and dangerous carnivora, which devour his cattle; round stations, cantonments, and villages it creates insanitary conditions.

Within the forest its effects vary to some extent with the class of forest concerned. In deciduous forests if fire enters a lantana-infested tract, which it is almost certain to do periodically, the conflagration is so intense that trees of all sizes may be killed outright, and immense damage to the crop may result. It is quite impossible to extinguish a fire raging through a thick growth of lantana, and two or three years after a severe fire the weed is as dense and luxuriant as ever, and profits by the opening of the overhead canopy. Again, natural reproduction of the light-demanding species, which are often the most valuable species, is effectually checked. Even sandal seedlings cannot survive long under a really dense crop of lantana. Still, when the lantana is removed in the manner described above, natural reproduction of tree species comes up plentifully on the cleared areas; lantana undoubtedly enriches the soil, and forms a clean germinating bed very favourable to natural reproduction when light is admitted. Mr. Tireman, in his paper already referred to, gives instances of profuse reproduction of *Anogeissus latifolia* on lantana areas from which the weed has been cleared after repeated burning, while teak, *Dalbergia latifolia*, *Pterocarpus Marsupium*, and other valuable species also regenerate freely on such areas.

Although fires are not so liable to occur in the evergreen as in the deciduous forests of southern India, they do sometimes take place in the former in dry years, and the damage done may be considerable owing to the susceptibility of the evergreen species to injury; in the event of fire an undergrowth of lantana may therefore prove to be a serious menace. On the other hand, although lantana persists in evergreen forest, it does not become luxuriant when the canopy is dense and may in time be killed out, while seedlings of the shade-bearing evergreen species are better able to establish themselves under its cover than those of the more light-demanding deciduous species. Thus except for the danger of fire, which is not always present, lantana in evergreen forests is not, as a rule, the serious pest which it may become in deciduous forests.

Although a serious scourge under many conditions, there are cases where the effects of lantana are beneficial to the forest. Owing to its soil-improving capacity it is a useful plant on poor shallow rocky soil. Where not too dense it may serve as a useful nurse to valuable species, and instances have been noted where it has been of considerable help in the establishment of sandal reproduction; it is sometimes held that lantana is connected with the spike

disease of sandal, a question which is discussed under *Santalum album.* So far as the forest is concerned, in areas where it has already monopolized the ground, the problem to be solved is how best to take advantage of its beneficial qualities and to minimize its injurious effects. Complete eradication over large areas is certainly a most expensive operation, but it may be justified in order to prevent the further spread of the pest, or where the risk of damage by fire is very serious, that is, where the forest crop is a sufficiently valuable one, for it may be regarded as almost certain that a lantana-infested area will be overrun with fire sooner or later. In Coorg, at all events, the forest management aims at a vigorous war of extermination against the lantana. On the other hand, the eradication of lantana over definite coupes annually, combined with the complete restocking of the areas taken in hand with valuable species by natural and artificial means, would be a satisfactory method of taking advantage of the special qualities of the lantana as an aid to reproduction. Apart from the question of fire, however, objection might be taken to partial eradication of this kind on the ground that the uncleared portions of the forest will remain centres of infection to cultivated lands in the neighbourhood or to recently felled coupes in the forest. The matter still requires much study, particularly in the direction of ascertaining the conditions of light and other factors under which lantana is unable again to take possession of the ground when it has once been eradicated and where its presence is undesirable. The planting or underplanting of an existing forest crop with heavy-foliaged species under which the lantana cannot thrive, is indicated as a possible subject for experiment. *Ficus elastica* has been tried for this purpose in Madras, but the successful establishment of this tree was not effected, and the experiment came to nothing. Mr. Tireman notes that the castor-oil plant checks the growth of the lantana considerably, but does not kill it.

Suggestions have been made that the lantana might be utilized commercially for the distillation of essential oil from its leaves or perfume from its flowers ; there may be possibilities in this direction. It is already used to some extent as fuel by villagers, but the amount consumed is negligible compared with the enormous quantities available.

INDEX TO SCIENTIFIC NAMES, VOLUME II

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